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PALLIATIVE IRRADIATION OF GASTRIC CANCER

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Radium and roentgen therapy have proved their worth in the treatment of cancer of the oral cavity, uterus, urinary bladder, skin, rectum and breast and of the various tumors of the lymphoid system. The stomach is the most frequent site of cancer, but unhappily it has not benefited by the advent of these new physical agents. Heretofore, radiation therapy has not been extensively employed in the treatment of gastric cancer because of the supposed radioresistance of this tumor and because of certain apparently insurmountable technical difficulties. We have been engaged for the past four years in the radiation therapy of cancers of the stomach chiefly in an attempt to afford palliation to the great number of patients with advanced inoperable cancers of this organ. This article is a recital of our experiences and conclusions concerning these experiments.

HISTORICAL REVIEW

Shortly after Roentgen announced his discovery of the x-rays, an article appeared describing the use of this new agent in the treatment of cancer. It is of considerable interest to note that the first cancer so treated was situated in the stomach. It was Despeignes [1] who in 1896 published this report of a gastric cancer treated by eighty exposures to the roentgen rays, each of from fifteen to thirty minutes' duration twice a day. The patient's condition was improved, and he was relieved from pain.

Not until almost two decades later were there reports of other cases of gastric cancer in which irradiation was used. Wickham and Degrais [2] in 1914 cited one case of pyloric cancer in which a preliminary gastroenterostomy was performed, an opening distal in the stomach being left through which radium could be inserted. The applications were con-

From the Memorial Hospital for Cancer and Allied Diseases.

1. Despeignes, V.: Observations on a Case of Cancer of the Stomach Treated by Roentgen Rays, Lyon méd. **82**:428 (July) 1896.

2. Wickham, L., and Degrais, P.: Radium and Cancer, New York, Paul B. Hoeber, Inc., 1914.

tinued for three months, a catheter containing radium being inserted into the stomach and directed toward the pylorus, while at the same time the palpable tumor received external irradiation through the abdominal wall. The patient was vastly improved in health for eighteen months following this therapy.

Janeway [3] in 1918 treated seven patients with cancer of the stomach. He applied radium externally in most cases, but in one instance the stomach was opened and the radium was inserted into the cavity. He considered the improvement, as indicated by the reduction in the size of the tumor as well as by subjective relief, to be sufficient justification for employing this method in the palliative treatment of gastric adenocarcinoma, which is usually discovered after it has reached an inoperable stage.

Levin [4] in 1922 advocated the insertion of bare glass capillary tubes of radon into gastro-intestinal and retroperitoneal cancers. He cited cases of duodenal and intestinal carcinoma in which improvement was due primarily to this treatment, which was given twice through two different laparotomy wounds. He disapproved of the use of roentgen irradiation in this connection because of the severe cachexia it was said to induce, and, furthermore, he stated that radium used externally was ineffectual.

Evans and Leucutia [5] (1923) reported twenty-five cases of carcinoma of the stomach in which high voltage roentgen rays were used. The improvement noted led them optimistically to declare that in combination with surgical measures irradiation might possibly eradicate all early gastric cancers. Two such cancers disappeared after treatment, as determined by roentgenographic study, but recurred eight and twelve months later. Some patients with ascites experienced considerable relief from this condition after irradiation through the abdominal wall. All patients had more or less subjective relief from pain, vomiting and hemorrhages for a number of months. The authors urged in describing their technic that the lungs and the adrenal glands be avoided by projecting films of the kidneys and stomach on the body to aid in marking the fields and tilting the tube correctly. Holfelder and Peiper [6]

3. (*a*) Janeway, H. H.: Gastroscopy, J. A. M. A. **61**:1339 (Oct. 11) 1913; (*b*) The Action of Radium in Cancer, Surg., Gynec. & Obst. **26**:233, 1918. (*c*) Janeway, H. H., and Green, N. W.: Esophagoscopy and Gastroscopy, Surg., Gynec. & Obst. **13**:245, 1911. (*d*) Janeway, cited in Ewing, J.: Early Experiences in Radiation Therapy, Am. J. Roentgenol. **31**:153 (Feb.) 1934.

4. Levin, I.: Intraperitoneal Insertion of Buried Capillary Glass Tubes of Radium Emanation, J. A. M. A. **79**:2074 (Dec. 16), 1922.

5. Evans, W. A., and Leucutia, T.: Results of Deep Roentgen Treatment of Gastro-Intestinal Malignancies, Am. J. Roentgenol. **10**:793, 1923.

6. Holfelder, H., and Peiper, H.: Die Strahlenempfindlichkeit der Nebennieren und Wege zur Verhütung von Nebennierenschaedigungen in der Röntgentiefentherapie, Strahlentherapie **15**:1, 1923.

published a report of experimental work on this subject in the same year, illustrating how a gastric tumor could be irradiated through three portals in such a way that one adrenal gland was always protected. It was stated that 60 per cent of a skin erythema dose to both adrenals is fatal. The dosage to the skin given by Evans and Leucutia [5] was from 110 to 130 per cent of a skin erythema dose through several portals cross-firing at the tumor. The factors of treatment were: 200 kilovolts; filter, 1.3 mm. copper and 1 mm. aluminum; port, 20 by 20 cm., and distance, from 40 to 60 cm. In their experience 140 per cent skin erythema dose is the maximum dose which does not damage the intestinal mucosa. They advocated a fat and acid-free diet and an abundance of alkalis for the patient together with cerium oxalate and essence of pepsin for radiation sickness.

In 1923 Neuman and Coryn [7] published a report of a case of carcinoma of the stomach with recurrence of the growth eleven months after subtotal gastrectomy in which radium needles were buried for six days, giving a dose of 3,456 milligram hours. The patient was comfortable, able to work and without symptoms for nine months. At that time external irradiation proved ineffective; the authors suggested that if the stomach had been fixed to the anterior abdominal wall at the time of the operation external irradiation might have been more successful.

Werner [8] (1925) described in detail such an operation for fixing an inoperable gastric tumor to the anterior abdominal wall so as to make it accessible for irradiation. It was originally suggested by Karl Beck and had been carried out by Werner and Caan and also by Wilms and Finsterer. The requirements for such a procedure are that the tumor must be movable and not too deeply seated. The irradiation is started a few days later, light doses (from one-half to three-fourths unit skin dose divided) being given, as a rapid breaking down of the tumor must be avoided. The anterior wall, made up of skin and peritoneum only, forms a scar which will contract, Werner said, and never develop a hernia. A repetition of the small doses is advised after from four to six weeks, although greater doses are indicated for the relief from pain in very advanced cases. Radium applied externally was said by this author to be ineffective.

Cahen [9] in 1923 also reported the treatment of two gastric cancers with radium used externally in moulages; both patients were in good health about ten months after the procedure.

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7. Neuman, F., and Coryn, G.: Récidive de cancer de l'estomac traité par l'aiguillage radifère, Cancer **1**:87, 1923.

8. Werner, R.: Tumoren des Magen-Darm-Traktes, in Gauss, C. J.: Lehrbuch der Strahlentherapie, Berlin, Urban & Schwarzenberg, 1927, vol. 2, p. 228.

9. Cahen: Cancer de l'estomac, Cancer **2**:42, 1925.

Schmidt [10] in 1928 reported the results of irradiation of twenty-nine inoperable and one recurrent gastric cancer. Of twenty-two patients followed, one was living and well three years later, the diagnosis having been proved by histologic section of tissue removed during an exploratory laparotomy. Holfelder [11] published the reports of two cases; in one the patient lived two and one-half years and in the other the patient died more than a year after roentgen therapy; in the latter case there was no evidence of tumor, although the clinical and roentgenographic findings had been indisputable.

Possibly this lack of enthusiasm and abortive attempts to use irradiation for gastric cancer were influenced by the authors of several books and papers which appeared at about that time. Ewing,[12] in an analysis of radiation therapy in 1924, classified gastric cancer among the tumors that were not then amenable to irradiation, although he stated that he had seen in section a carcinoma of the pylorus which had been destroyed by irradiation. He also remarked that some palliative results had appeared remarkable. Laborde [13] (1925) wrote that cancer of the digestive tract other than that of the esophagus and rectum does not seem to be aided sufficiently by radiation therapy to warrant mention. Waring [14] (1928) mentioned radiologic methods in his book and stated that his experience was limited to the external application of radium for inoperable gastric cancer. F. C. Wood [15] classified the cells of cancer of the gastro-intestinal tract with melanoma as having a specific resistance to irradiation. Persons with gastric cancer are not even accepted for radiation therapy at Radiumhemmet in Stockholm.

Holfelder,[16] however, continued to write about and hope for results in the treatment of cancer of the stomach, and in 1931 he advocated the use of a compression diaphragm to exclude the organs overlying the tumor by pressure and the replacement with air, as much as possible, of the distance between the target and the tumor. He said that over a hundred gastric cancers had been so treated and recalled two

10. Schmidt, W.: Die Ergebnisse der Röntgentherapie bösartiger Geschwülste an der chirurgischen Universitätsklinik zu Göttingen in den Jahren 1919-1927, Strahlentherapie **30**:201, 1928.

11. Holfelder, H.: Wass kann man heute von der Röntgentherapie der sogenannten inoperablen Tumoren erwarten? Strahlentherapie **33**:131, 1929.

12. Ewing, J.: An Analysis of Radiation Therapy in Cancer, Radium Report of Memorial Hospital, second ser., 1923, New York, Paul B. Hoeber, Inc., 1924.

13. Laborde, S.: La curiethérapie des cancers, Paris, Masson & Cie, 1925.

14. Waring, H. J.: Surgical Treatment of Malignant Diseases, New York, Oxford University Press, 1928.

15. Wood, F. C.: Cell Resistance Incited by Radiation, Am. J. Cancer **16**: 1247 (Sept.) 1932.

16. Holfelder, H.: Methodische Fortschritte der Röntgentherapie der Kresbse des Verdauungskanals, Strahlentherapie **42**:497, 1931.

patients who lived one year and two and one-half years, respectively, after treatment. The diagnosis in these cases had been verified before treatment by exploratory laparotomy and by biopsy. Von Haberer [17] (1931) and Boas [18] (1931) both mentioned the postoperative use of radiotherapy for prophylaxis and for recurrent and inoperable cancers. Yeomans [19] in 1933 cited the instance of a patient who lived two years and ten months after treatment consisting of gastro-enterostomy and interstitial irradiation by gold radon seeds.

Gosset, Monod and Regaud [20] recently reported their results in the treatment of thirty-one patients with gastric cancer at the Radium Institute of Paris. With all conditions equal, these authors expressed the opinion that the gamma rays of radium are more elective therapeutically than the roentgen rays—an observation verified in our present thesis. The treatment was limited to the external application of radium, a radiating surface of 150 sq. cm., a skin distance of only 10 cm. and multiple skin ports being used. At the beginning of their clinical experiment the authors raised the question whether or not the cure of gastric adenocarcinoma by irradiation would necessitate the administration of a dose of radiation incompatible with the integrity of the normal mucosa of the digestive tube. Thirty-one gastric cancers, thirty of which were diagnostically verified by exploratory laparotomy, were treated by this method. Seventeen of the patients had no amelioration of symptoms and no prolongation of life. In seven definite improvement was observed; but the duration of survival was not increased. In the remaining seven an important and considerable betterment in health was accompanied by a notable prolongation of life. The results in this group were as follows: One patient was cured for six and one-half years, another patient was living after thirty-three months and five patients died after eleven, twelve, sixteen and twenty-one months and four years and nine months. Two factors exerted an unfavorable influence on these results: the poor general state of the patient and the radioresistance of the cancers. The radiosensitivity of gastric cancer is held to be extremely variable, as judged by the great discordance in comparing the doses with the results of irradiation. Gosset, Monod and Regaud considered the most fertile field for their scientific experiment to be the local recurrences after gastrectomy, as here they were

17. von Haberer, H.: Magen und duodenal Krebs, Neue deutsche Klin. **7**: 90, 1931.

18. Boas, I.: Der Magenkrebs, Neue deutsche Klin. **7**:59, 1931.

19. Yeomans, F. C.: Care of Advanced Carcinoma of the Gastro-Intestinal Tract, J. A. M. A. **101**:1141 (Oct. 7) 1933.

20. Gosset, A.; Monod, O., and Regaud, C.: Traitement des cancers gastriques inextirpables par le radium à distance, Bull. Acad. de méd., Paris **110**:379 (Nov. 21) 1933.

supplied with the original tumor for histologic analysis and evaluation of radiosensitivity. They agreed that gastrectomy or pylorectomy is preferable to radiation therapy whenever the cancer is operable.

EXPERIMENTS IN IRRADIATION OF THE NORMAL STOMACH

The histologic and functional changes induced by irradiation of the normal stomachs of animals and human beings have been thoroughly studied. Regaud, Nogier and Lacassagne [21] in 1912 irradiated the abdomens of dogs with roentgen rays with the production of acute or chronic gastric ulcers, depending on the dosage and the time of survival of the animal. Ghilarducci [22] (1914 and 1916) observed that roentgen irradiation of rabbits caused the chief cells to disappear earlier than the parietal cells; this differential sensitivity was later confirmed by Regaud and Lacassagne.[23] Radium placed within the cavity of the stomach also destroyed the chief cells first; these cells were replaced by the hypertrophic parietal cells, which subsequently disappeared. The mucous cells finally lost their function and slowly degenerated. Tsukamoto irradiated the livers of rabbits and produced hemorrhages and ulcers in the gastric mucosa. No definite alterations were found in the stomachs of dogs after exposure of other parts of their bodies to the roentgen rays.

The functional disturbances in the stomachs of dogs following roentgen irradiation were fairly constant; single small doses evoked no change; larger doses caused the acidity to fall sharply each time, to remain low for several days and then to rise gradually, returning to normal after the irradiation was discontinued. The pepsin content fell slowly after repeated exposures and rose sluggishly back to normal during the postirradiation period. Roentgen irradiation of the stomachs of patients with simple hyperchlorhydria and hyperacidity associated with chronic ulcer caused in the majority of cases a reduction in the gastric acidity, both free and total. This change was more rapid for simple hyperchlorhydria, but in all instances it was transient after a single exposure, returning to normal in twenty-four hours. With each subsequent roentgen treatment the acidity was still more reduced and the effect was more lasting. The greatest diminution followed when the initial acidity was highest. Radiotherapy for gastric ulcer has been

21. Regaud, C.; Nogier, T., and Lacassagne, A.: Action mocive des rayons X sur le tube digestif, Paris méd. **8**:489, 1911-1912.

22. Ghilarducci, cited by Desjardins, A. U.: Action of Roentgen Rays and Radium on the Gastro-Intestinal Tract, Am. J. Roentgenol. **26**:145 (July); 335 (Aug.); 493 (Sept.) 1931.

23. Regaud, C., and Lacassagne, A.: Effets des radiations sur les muqueuses du tube digestif, sur les épithéliums de revêtement et sur les glandes exocrines et endocrines, Radiophys. et radiothérapie **1**:70, 1930.

attempted independently by Matoni and Strauss, who reported considerable initial improvement. Winternitz (1911) added radium emanation to water or test meals given to normal subjects and to patients with hypo-acidity and hyperacidity. He found no changes in the acid or pepsin content of the succus gastricus or in the gastric motility.

DISADVANTAGES AND DANGERS IN IRRADIATION OF GASTRIC CANCER

We may enumerate briefly the apparent disadvantages attendant on radiation therapy of gastric cancer. First, the stomach is an essential organ needed daily for the ingestion of food. It is at the gateway of the alimentary canal, and the preservation of its function together with the appetite and the ability to utilize a minimal amount of food is absolutely necessary for the integrity of the patient. If it were possible for the stomach to have complete rest for six weeks during the progress of the treatment, the results would be much more satisfactory. The inaccessibility of the stomach is another disadvantage if one compares it with the uterus, skin, mouth, rectum and breast, which are readily accessible to roentgen irradiation and to the implantation of radium. The stomach is so deep within the body cavity that in all attempts to treat a tumor of this organ with roentgen rays or radium delivered from external sources only a small percentage of the dose on the skin reaches the tumor substance. It is a mobile organ and is not constantly in the same relation to the anterior and posterior abdominal walls, to which the irradiation must be given. The difficulty of delivering a depth dose of any magnitude is of great importance when one realizes that the majority of carcinomas of the stomach are radioresistant tumors.

To increase the tissue dosage of radiation in cases of cancer of the stomach would require the implantation of radium by a laparotomy. Hence one may appreciate that the surgical approach for interstitial irradiation of carcinoma of the stomach is a more dangerous procedure than for radium therapy of any other tumor, with the exception of a neoplasm of the brain. It is far more serious than the surgical exposure of metastatic carcinoma in cervical, axillary or inguinal lymph nodes, than suprapubic cystotomy for the implantation of radium in the bladder or than laryngotomy for the treatment of laryngeal carcinoma. The mortality rate from the operation alone is not insignificant. Direct examination of the interior of the stomach by means of the gastroscope, while possible and useful at times in obtaining specimens for biopsy, does not offer a practical means of inserting radium into the gastric cancer.

One of the major obstacles in radiation therapy is the same that confronts the surgeon, namely, the advanced stage of the tumor when the diagnosis is made, i. e., the state of inoperability. This militates

against successful treatment by radium and roentgen rays just as it removes the possibility of complete surgical extirpation. As long as the carcinoma is confined to the stomach there may be means of overcoming the technical difficulties of implanting sufficient radium or delivering a depth dose of radiation from external sources sufficient to control the carcinoma, but when metastasis has occurred to the liver or the peritoneum the patient is beyond all hope even of palliation from irradiation. This is due to the fact that the liver parenchyma is as sensitive as the carcinoma to the effect of irradiation: There does not exist that selective radiosensitivity on which successful radiation therapy depends.

One of the essential requisites for good results in the irradiation of carcinomas of other organs is that the patient be in good general health. In cases of gastric cancer this is seldom the case; most of the patients are emaciated, cachectic, anemic, undernourished and unable to face the rigor and ill effects of a long program of radiation therapy.

The close proximity of such organs as the liver, pancreas and adrenal glands to the majority of gastric cancers handicaps the radiologist in the use of external irradiation. Only by careful localization of the gastric tumor and selection of the region for irradiation is it possible to administer this treatment without consequent injurious effects on these adjacent labile organs. The so-called radiation sickness is a common accompaniment of external irradiation of almost all parts of the body, but it is particularly frequent and severe following roentgen irradiation of the upper portion of the abdomen. Radiologists have avoided direct irradiation in cases of mammary cancer by directing the beams tangential to the chest, but such a procedure is not possible in the deep tumors, such as those of the stomach. The severity of the radiation sickness following the treatment of gastric cancer may greatly delay convalescence; furthermore, it may be so distressing during the treatment that it limits the amount of radiation which may be applied besides increasing the time during which the treatment is given, this being a most important factor.

Many carcinomas of the stomach are situated at one of the gastric outlets, the cardia or the pylorus. These cancers are first made manifest frequently by symptoms of obstruction. A patient with partial or almost total obstruction either at the cardia or at the pylorus is certainly not a fit subject for irradiation. In such a case surgical intervention is indicated and radiation therapy reserved as a postoperative measure. We have been able to bring about improvement in cases of partial obstruction of the pylorus or the cardia, but if the obstruction is nearly complete the urgency is too acute to wait for the late effects of radiation therapy as it requires from three to six weeks for the results to become evident.

Practically all gastric cancers are infected, and infection diminishes the radiosensitivity of any cancer. During the first few days of irradiation fever may develop, suggesting that the infection has increased, but later the fever vanishes and the evidences of infection also disappear.

The stomach being a hollow viscus, the dangers caused by the implantation of radium in its wall are considerable. Great accuracy in the implantation of radium is necessary, since all precautions must be taken to prevent leakage of the gastric contents at the time of treatment as well as later due to overdosage. The dangers of radionecrosis are greater than in any other organ with the exception of the esophagus. If treated carcinomas become necrotic when situated in the skin, mouth or other locations they are accessible to treatment, but radionecrosis of the gastric wall may lead to a fatal hemorrhage, perforation causing peritonitis or perforation into another abdominal organ, such as the colon, with a resultant gastrocolic fistula.

The removal of a biopsy specimen for microscopic study of the tumor and an evaluation of its radiosensitivity and histologic grading is an important preliminary step in the radiation treatment of most cancers. It is difficult to obtain this tissue from gastric cancer except by laparotomy or occasionally by gastroscopy.

INDICATIONS FOR AND ADVANTAGES OF IRRADIATION IN THE TREATMENT OF CANCER OF THE STOMACH

Irradiation is not proposed as a substitute for resection of the stomach with cancer in an operable stage. Its chief indication is in the treatment of gastric cancers classified as inoperable because of the extent of the disease or because of some particular location of the tumor such as in the cardia or the fundus. As inoperable gastric cancers are inevitably fatal if untreated, nothing has been lost by the institution of radiation therapy under these circumstances.

The surgeon occasionally sees a patient with an apparently operable gastric cancer who will not consent to any operative procedure or whose physical condition will not permit radical surgical procedures. In such situations the only recourse left has been to attempt palliative irradiation. Although the technical and biologic handicaps to the successful irradiation of gastric cancer are so numerous, it seems that considerable experimentation in the methods of irradiation may surmount these difficulties in part.

Like other organs, the stomach has its quota of radiosensitive carcinomas, although this type is not relatively as frequent in the stomach as in the tonsil, cervix and lymphoid tissues. It is esimated that less than 10 per cent of gastric cancers may be classified as radiosensitive, but a greater percentage will respond in some degree to well planned radiation therapy.

Obstructive inoperable carcinomas of the cardia and pylorus are best treated by such palliative operations as gastrostomy and gastrojejunostomy, respectively, but when these are contraindicated by the patient's age or physical condition or when one fails to obtain consent for operation, radiation therapy has, in some cases, given temporary relief from the obstruction. This improvement is estimated clinically by the patient's ability to swallow solid food if the cardia is involved or by the diminution in the retention of gastric residue after six and twenty-four hours, as observed in roentgenograms made after the ingestion of a barium sulphate meal. If these short-circuiting operations are possible, they are followed by irradiation as a supplementary palliative procedure.

In the published operative statistics from various hospitals one observes quite frequently the great proportion of exploratory laparotomies which are done for inoperable carcinomas of the stomach. In such cases the surgeon is content with ascertaining the extent of the growth and possibly with securing a biopsy specimen. Under such circumstances it does not entail much additional risk to treat an inoperable carcinoma at this time with radium applied interstitially. No surgeon could be censured for the use of radium under these conditions.

RADIOSENSITIVITY OF GASTRIC CANCERS

The majority of cancers of the stomach are radioresistant, less than 10 per cent exhibiting clinical improvement and roentgenographic evidence of regression following moderate exposure to external irradiation. As we shall point out later, the most radiosensitive gastric cancers are located in the cardia and the fundus.[24] Our experience has not been sufficient to identify with certainty the radiosensitive varieties of gastric cancer, but we have empirically formulated some opinions based on the gross anatomic classification of Ewing.[25] The bulky adenocarcinoma is a circumscribed sessile fungating tumor occasionally developing from an adenomatous polyp. When situated at the cardia or in the fundus, this tumor may partially regress following external irradiation, although it is more prone than most tumors to undergo necrosis and deep ulceration with consequent hemorrhage or perforation. The rare subgroup of villous tumors (papillary adenoma malignum) is composed of well developed branching vascular papillae (fig. 1) which shrink following radiation therapy by a process of obliterative vascular changes and infarction.

24. Stewart, F. W.: Radiosensitivity of Tumors, Arch. Surg. **27**:979 (Dec.) 1933.

25. Ewing, J.: Neoplastic Diseases, ed. 3, Philadelphia, W. B. Saunders Company, 1928; footnote 3d.

The gelatinous carcinoma of the stomach, like its congeners in other organs, is endowed with the same degree of radioresistance as the normal stomach, or a greater degree. All varieties of gelatinous carcinoma, including the infiltrating signet-ring cell type, are composed of well differentiated adult cells in a gelatinous stroma, which constitutes a tissue bed most unfavorable to changes produced by irradiation.

Fig. 1.—Papillary adenoma malignum of the stomach, of grade 1 and radiosensitive.

Furthermore, the gelatinous cancer penetrates the gastric wall early and widely involves the peritoneum, thus offering a further handicap even to palliative irradiation.

Ewing [26] predicted that we would occasionally discover a radiosensitive ulcerocancer, and his prophecy has been verified by an astonishing regression and palliation in two histologically verified cases in

26. Ewing, J.: Radiosensitivity, Radiology **13**:313, 1930.

which the tumor was treated by intensive external irradiation (case 3). The carcinomatous ulcer is usually a small alveolar cancer and possesses none of the histologic earmarks tokening radiosensitivity.

The carcinoma telangiectatica is a large, round, circumscribed ulcerating tumor occurring chiefly in the fundus and the cardia. It is the type of medullary cancer or carcinoma simplex often associated with

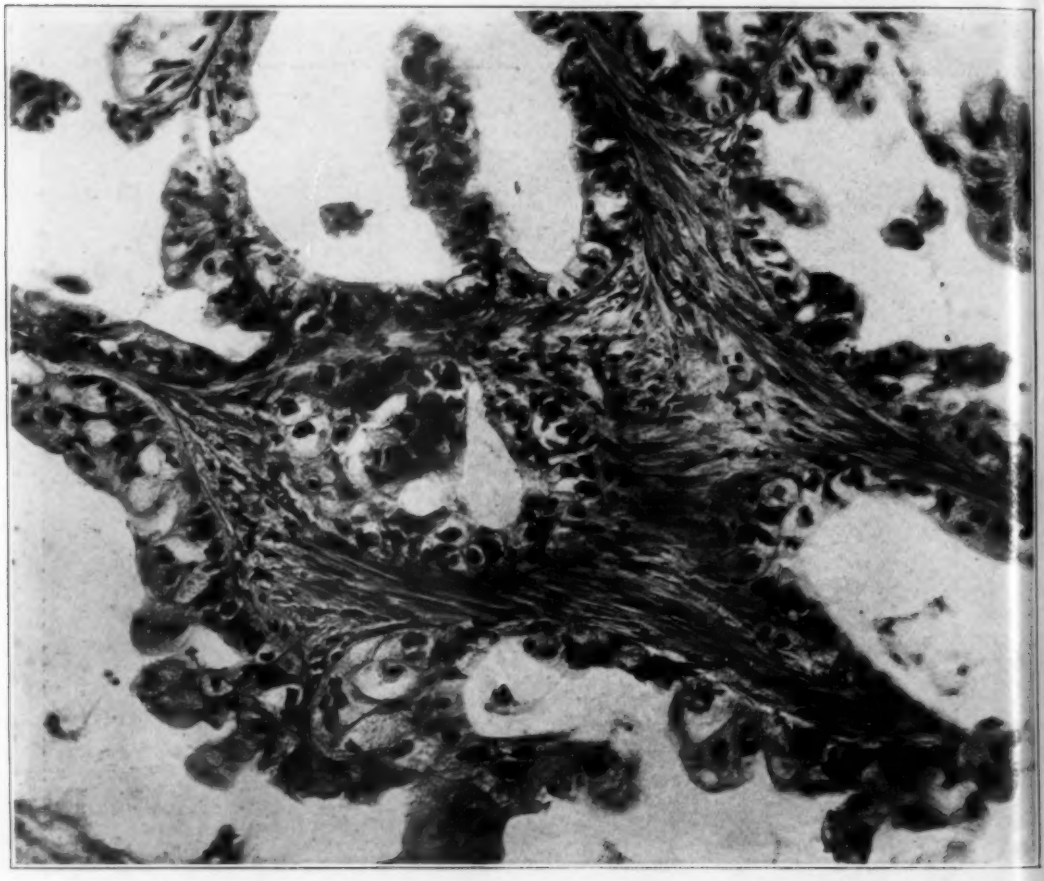

Fig. 2.—Papillary adenoma malignum of the stomach, of grade 2 and radioresistant.

profound anemia because of continuous or intermittent hemorrhages. We have had several patients with this type of carcinoma who have been decidedly improved by roentgen or radium treatment (case 2 and 4).

Ewing [27] has observed that the small cell cancers originating from the base of the gastric glands constitute a radiosensitive group. There

27. Ewing, J.: Tissue Reactions to Radiation, Am. J. Roentgenol. **15**:93, 1926; Factors Determining Radioresistance in Tumors, Radiology **14**:186, 1930.

is a certain anaplastic small cell gastric cancer which bears a close morphologic resemblance to lymphosarcoma and is sensitive to irradiation. Such a tumor may be entirely lacking in desmoplastic properties and extend diffusely as a small alveolar or solid tubular growth over the mucosa or intramurally.

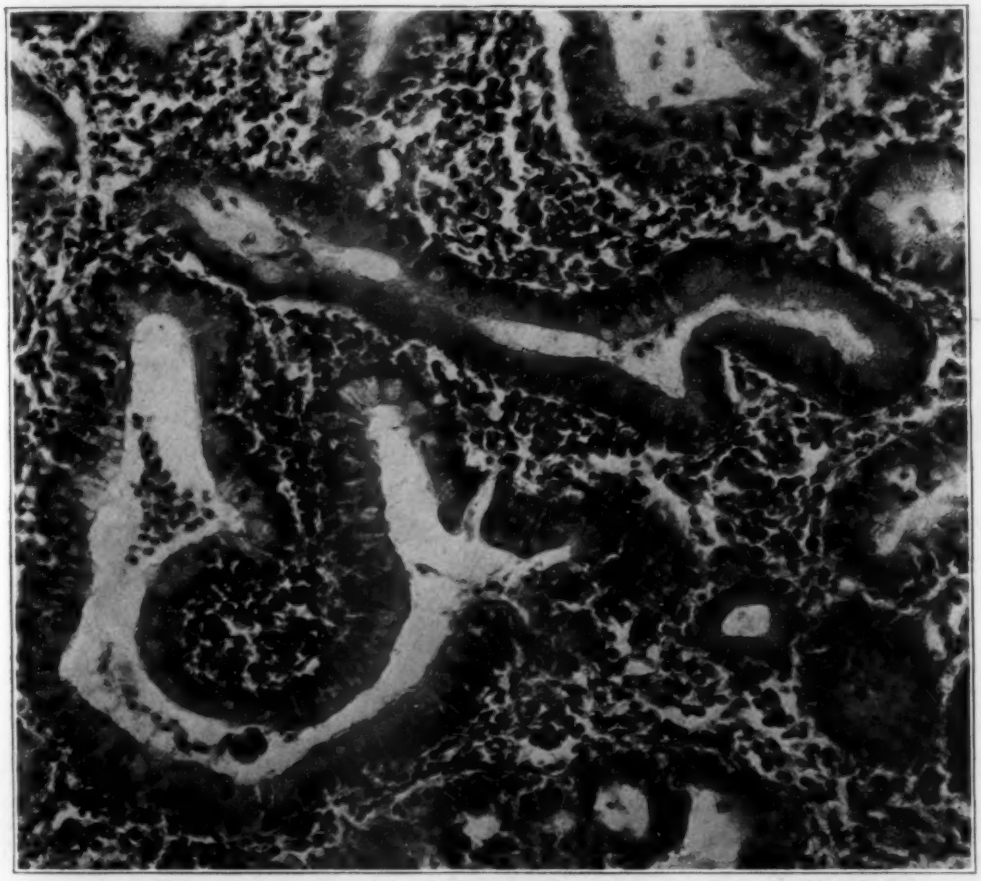

Fig. 3.—Adenoma malignum of the cardiac orifice, of grade 2 and radioresistant. There is considerable lymphocytic infiltration of the stroma.

The diffuse scirrhous carcinoma (linitis plastica type) and fibrocarcinoma are by their very nature unresponsive to irradiation. The opposite extreme in radiosensitivity is the rare primary lymphosarcoma of the stomach. One of our patients with an inoperable sarcoma of this type from which a biopsy specimen was obtained is now living six years after treatment by the radium element pack (case 1).

PREPARATION OF THE PATIENT FOR RADIATION THERAPY

If a patient is to be subjected to irradiation the stomach should not contain food at the time of treatment. This is secured either by control of the diet during the period of treatment or by using liquid and semi-solid food that rapidly leaves the stomach. Another valuable adjunct

Fig. 4.—Superficial adenoma malignum of the stomach with gelatinous degeneration. There are multiple foci of origin visibly continuous with normal gastric glands. The adjoining mucosa is the site of hypertrophic gastritis.

is the use of gastric lavage. The patient should have the same careful preparation as for operation on the stomach, although not so arduous. Gastric lavage is useful to remove residue and to lessen the infection of an open ulcerated carcinoma. Lavage should be continued daily if

possible until the gastric contents remain clean. This is essential, as infection constitutes a dangerous risk for radiation therapy for two reasons: (1) Irradiation increases the amount of necrosis of the tumor and permits infection to gain headway, and (2) in the presence of

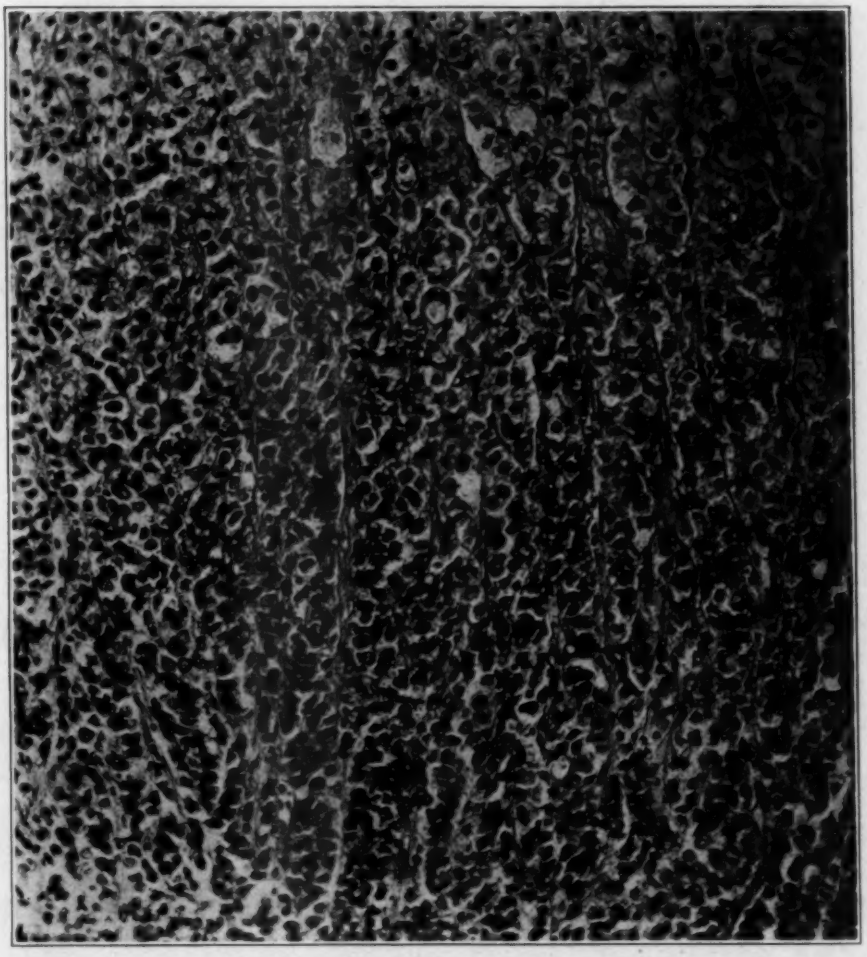

Fig. 5.—Diffuse tubular superficial carcinoma of the stomach, of grade 3 and radiosensitive. It involves the entire gastric mucosa in all subdivisions of the stomach.

infection irradiation may lead to such massive necrosis that hemorrhage occurs.

When external irradiation is employed, it should be given in the morning. During the remainder of the day the patient is limited to a liquid or semisolid diet, which is of high caloric content and is well

balanced. Because of the close proximity of the liver and pancreas to the stomach the patient suffers greatly from the immediate constitutional reaction following external irradiation. One of the best means to combat this reaction is to insure an abundant intake of fluid, such as water in large quantities, orange juice strained through a cloth, grapefruit juice, ginger ale, etc. If insufficient fluid is given by this means it may

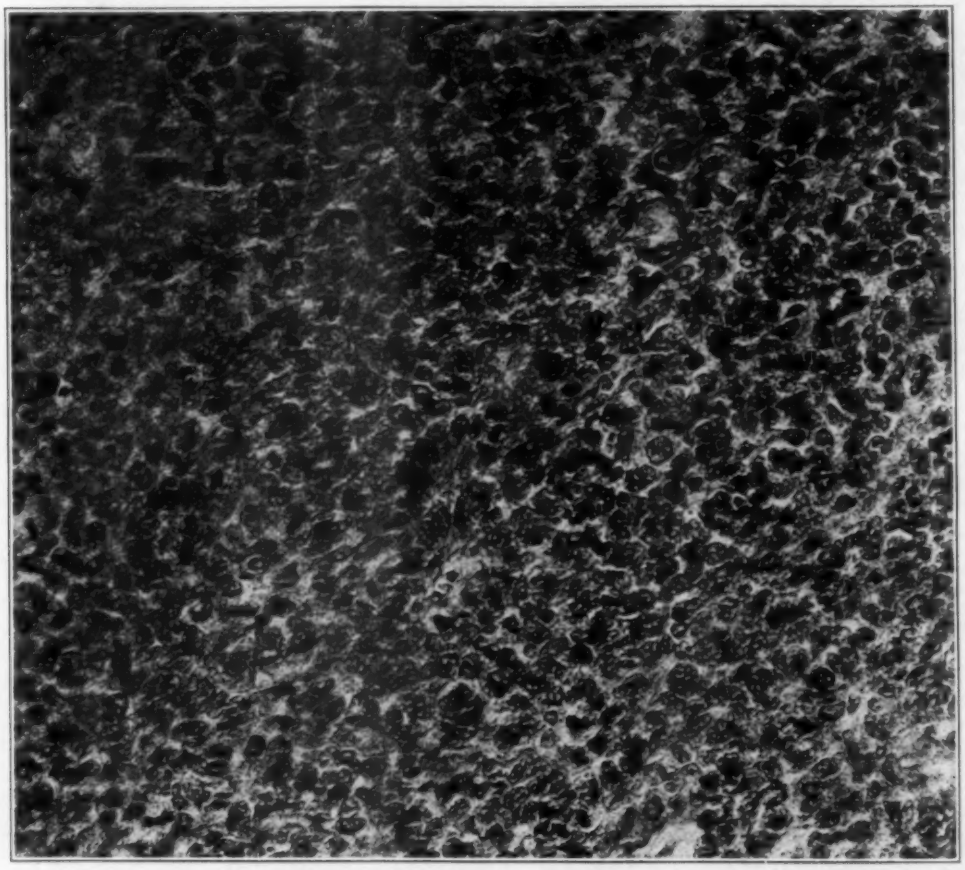

Fig. 6.—Cellular anaplastic carcinoma of the stomach. There is insufficient differentiation of this carcinoma to identify it as of gastric origin. The anaplasia, numerous mitoses, absence of desmoplasia and hyperchromatism of the nuclei indicate that this carcinoma is radiosensitive.

be necessary to supplement the fluid intake by hypodermoclyses of physiologic solution of sodium chloride or by intravenous infusions of dextrose solution. The cause of radiation sickness is probably the partial depletion of glycogen in the liver; therefore, the administration of dextrose intravenously as well as candy by mouth, if tolerated, is a

rational procedure. Other methods helpful in combating radiation sickness are: the administration of sodium bicarbonate after meals and the use of viosterol (from 8 to 10 drops daily), tomato juice twice daily and calcium lactate by mouth.

The patient undergoing roentgen or radium treatments should not work but should rest a considerable part of the day. The mouth should be cleaned and infected teeth cared for in order to avoid infection of the gastric carcinoma. If the patient is anemic it is most essential to give one or more blood transfusions. The advantages of this are several. It increases the strength and vigor of the patient, it enables him to tolerate the rigor of intensive irradiation, and it contributes in some intangible way to a more effective irradiation of the tumor or rather to a better response of the tumor to irradiation.

PHYSICAL FACTORS IN THE RADIATION THERAPY OF GASTRIC CANCER

The action of radiation in causing regression of the tumor is generally conceded to be a direct effect on the tumor cells themselves and on the tissue immediately surrounding them. This means that the only radiation which is effective is that which reaches the region of the growth. In order to practice radiation therapy to the best advantage, therefore, it is essential to find out how much radiation may be expected to produce a given effect and then to devise means for delivering this quantity to the tissues in question.

It is usually true that different points in an irradiated mass do not receive the same amount of radiation; this is inevitable when interstitial sources are used. If regression of the tumor depends on every point receiving at least a definite quantity, then it is necessary to know the minimum dose delivered at any point within the lesion. This is the tissue dose referred to in the discussion on radiation therapy. It is of interest to know the amount of radiation leaving the source, because, other things being equal, the more powerful the source the shorter the time of treatment. It is important to know the quantity falling on a given skin area, since skin tolerance limits the dose which can be given through any one field. Neither of these, however, is of much value without the knowledge of the amount actually reaching the diseased cells.

For the expression of quantity it is necessary to adopt a unit. Various units have been proposed for measuring "doses" of radiation; none of them is very satisfactory, and none has been officially adopted. At the Memorial Hospital the unit is the so-called "threshold erythema dose" (T.E.D.), defined as the amount of radiation which, administered at a single exposure, will produce a visible tanning or reddening of the

skin in from two to four weeks' time in 80 per cent of the cases and no visible effect in the others. This dose can be determined experimentally for any given type of radiation with considerable accuracy. The roentgen, which is the accepted unit for specifying the output of the x-ray tube, is not suitable for expressing tissue doses. By definition it is a quantity of radiation measured by an effect produced in air under specified conditions. It is at present established only for the roentgen rays generated within a certain range of voltage; it has not been satisfactorily extended to very high voltage roentgen rays or to the gamma rays of radium. Morever, when the measuring instrument is placed on or in a mass of matter, in addition to the direct or primary beam of radiation, it is affected by the rays scattered into it from the surrounding substances. The relative amount of this "back scatter" under conditions of therapy has not been satisfactorily determined. Since the scattered radiation is automatically included in the erythema dose when it is determined experimentally, this difficulty does not arise when that unit is used.

For the measurement of radiation within the tissues, no direct method is at present available. In order to obtain approximate values, it is necessary to make certain assumptions, based on the results of experiments performed outside the body. The most common method is to determine, with a small ionization chamber, the intensity of radiation on the surface of a tank of water (a so-called water phantom) and the relative intensities at various depths. It is then assumed that in a volume of tissue comparable to that of the phantom, with the same beam of radiation, the intensities at various levels will be the same as those in the water. Thus, if the ionization measurements indicated at a depth of 10 cm. an intensity of 33 per cent of that on the surface, it is assumed that if 1 threshold erythema dose falls on the skin, one third of a threshold erythema dose is delivered at a depth of 10 cm. This would be true if the quality of radiation remained the same. As a matter of fact, it is altered somewhat in its passage through matter, and after it has traversed several centimeters the change may be considerable. The action of this changed (less penetrating) radiation may be different in the production of ionization and of erythema. There is some evidence to show that for 200 kilovolts roentgen rays the difference is not great, so that the assumption in this case would be justified. With gamma rays from external sources, on the other hand, the difference may be considerable; there are at present few data on which to base an opinion.

It is also necessary in discussing physical measurement of the dosage of radiation to emphasize the importance of the time factor. This is not a physical factor and is not taken account of by physical measure-

ments. Laboratory instruments if sufficiently sensitive will register the same total effect from a given quantity of radiation whether it is administered all at once or subdivided in any of the ways customary in clinical irradiation. The biologic response under these different conditions, however, may vary a great deal. This should be borne in mind in connection with any discussion of tissue dosage.

There are two methods by which radiation may be delivered to a malignant growth within the body. In one, the source of the roentgen rays is external—either an x-ray tube or a radium applicator such as the large pack. From such a source the rays must pass through skin and other normal structures before they reach their objective. In the other, the source consists of one or more small tubes or needles containing radioactive material, introduced directly into the growth or the region immediately surrounding it. In this case, the rays arrive at the diseased tissues without having first to traverse normal ones.

These two methods will be considered somewhat in detail, particularly with regard to their applicability to treatment of cancer of the stomach. In the first, a beam of the roentgen rays or gamma rays will be directed toward the region of the body which is, as nearly as can be determined, directly over the lesion. If the mass is situated, for example, 10 cm. below the surface of the body, these rays must then traverse 10 cm. of tissue before they arrive at the malignant growth. In doing so, a considerable proportion of them will be absorbed or scattered from their direct route.[28] Also, because the beam spreads as it advances, less radiation will fall on a unit area 10 cm. below the surface than on a unit area on the skin. For all these reasons, with the usual x-ray set-up employed in the treatment of gastric carcinoma or with the large radium pack used under the most favorable conditions, only about one third of the radiation incident on the skin reaches a depth of 10 cm. It is possible by increasing the filter, by increasing the target skin distance or by increasing the field to increase the relative depth dose somewhat, but with the facilities generally available at present it cannot be brought up to more than one half of the skin dose in any practicable manner. Moreover, it must not be lost sight of that increases produced by the first two of these methods are very uneconomical. By increasing the filter in the x-ray beam from 0.5 mm. of copper to 2 mm. of copper, the dose at a depth of 10 cm. can be increased about 6 per cent, but the intensity of the beam is so much decreased by this additional filter that an exposure almost three times as long is required to deliver the same dose on the

28. Lee, B. J.; Pack, G. T.; Quimby, E. H., and Stewart, F. W.: Irradiation of Mammary Cancer with Special Reference to Measured Tissue Dosage, Arch. Surg. **24**:339 (March) 1932.

skin. Increasing the target skin distance from 50 to 70 cm. increases the depth dose by about 10 per cent but doubles the time of irradiation necessary to deliver a given skin dose. It is clear, then, that there is an economic limit to gains in depth dosage obtained by such means. Increasing the size of the field from 10 by 10 cm. to 20 by 20 cm. increases the dose at 10 cm. depth by about 20 per cent. This appears desirable, but it should be noted that a large part of the vital organs, which may be partly avoided with a small beam, will inevitably receive doses of radiation, in some cases greater than that delivered to the tumor. Some of these organs are quite radiosensitive and should be protected if possible.

There remains the method of increasing the depth dose by irradiating through more than one area—the method of "cross-fire." If the lesion is situated about half-way through the body, the use of a posterior field directly opposite the original anterior one will double the dose delivered at the growth. The use of lateral fields in addition would increase the dose still more, but this procedure is open to the same objection as the increase in size of the anterior and posterior fields, namely, the increased irradiation of normal organs.

All that has just been said about relative depth doses holds true no matter what quantity of radiation is delivered on the skin. If one erythema dose is delivered to an anterior and a posterior field, with an abdomen 20 cm. in diameter, the region in the middle will receive two thirds of an erythema dose, one third from each field. If each area receives only one half of an erythema dose, the central region gets a total of two sixths of an erythema dose. When daily doses of radiation as small as this are given they may be repeated without permanent injury to the skin, until a great deal more radiation has been given than would be possible with a single treatment. If one half of an erythema dose is given daily, anterior and posterior fields being irradiated on alternate days, it is possible to give as many as several erythema doses per skin field. But the same proportion holds, and the tumor at the center will receive just two thirds as much as a skin field.

Four erythema doses subdivided in this manner will not produce much more reaction in the skin than 1 erythema dose delivered at a single exposure. It is, therefore, not obvious that two and two-thirds erythema doses delivered into the tumor during this treatment will produce a more marked effect than two thirds of an erythema dose delivered from two single exposures. From a purely physical point of view it would not be expected to. Interestingly enough, in clinical experience with some types of neoplasm, the larger dose, divided over a number of treatments, does produce a more marked effect on the tumor than the single smaller one. It seems that this must be due to a difference in the rate of recuperation between the normal and the diseased

cells. The normal cells recover well from the effects of the partial dose, so that the next treatment finds a fairly healthy cell. The tumor cells, on the other hand, do not recover so well, and the next dose of radiation falls on a partially disabled cell. If the reverse were true and the malignant cells recovered more quickly than the normal, then the single intense irradiation would be the method of choice. If the rates of recovery were the same, the subdivision of irradiation would make no difference. It is only by experience in the treatment of each type of disease that the best method for different lesions can be determined. It cannot be assumed that because one growth in one part of the body responds well to a given sort of treatment any other type will behave in the same manner.

Even with the advantage gained by divided and protracted treatment in favorable cases, the quantity of radiation which it is possible to deliver by external irradiation to the average lesion of the stomach within a reasonable period of time is considerably less than that which has been found necessary to produce regression of squamous carcinoma in other parts of the body. Figures 7 and 8 show the distribution of radiation throughout the upper portion of the abdomen in percentages of the amount falling on the skin for the two types of external irradiation most commonly used in gastric cancer.[29] In figure 7 the roentgen rays generated at a 200 kilovolt peak, filtered through 0.5 mm. of copper and 2 mm. of aluminum, with a target skin distance of 50 cm., fall on single anterior and posterior fields of 100 sq. cm. each. In figure 8 the radium element pack, with a skin distance of 15 cm., irradiates the same regions. The field for this set-up cannot be limited to 100 sq. cm., nor can it be exactly defined. From these diagrams it is seen that when one threshold erythema dose (100 per cent) falls on each of these two skin fields, as was previously stated, about two thirds of an erythema dose will be delivered throughout the region of the stomach. A possible total of six threshold erythema doses per field, delivered within one month, would deliver about four threshold erythema doses to the lesion.

In certain cases it may be possible to supplement external irradiation by the second method mentioned, the interstitial implantation sources. For rather small, accessible circumscribed lesions, this type of treatment seems to be ideal. The radiation is delivered exactly where it is needed; the tumor cells receive more than the normal ones; unaffected organs are, in general, far enough away not to be damaged, and the general or constitutional reaction is minimized.

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29. Quimby, E. H., and Pack, G. T.: The Skin Erythema for Combination of Gamma and Roentgen Rays, Radiology **13**:306, 1929; Further Studies on the Skin Erythema with Combinations of Two Types of Radiation, ibid. **15**:30, 1930.

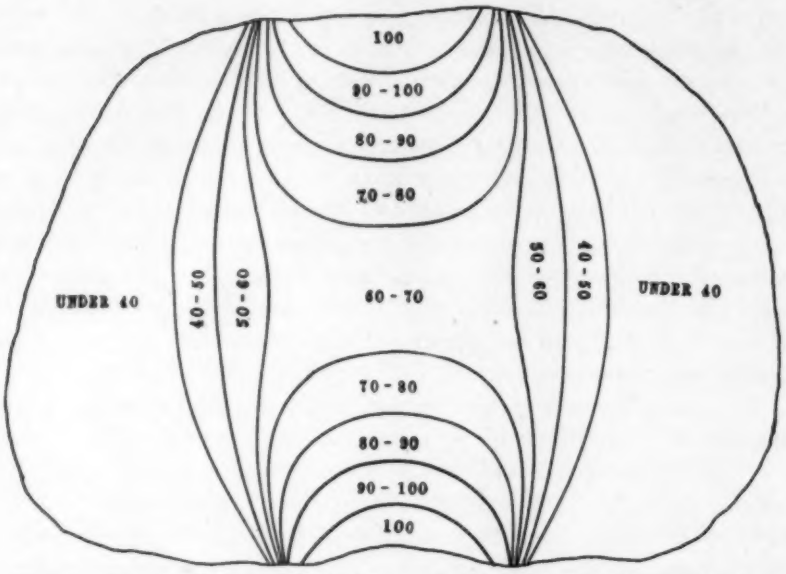


Fig. 7.—Cross-section of the body at the level of the pylorus showing the distribution of radiation from the x-rays. The factors of treatment are: 200 kilovolt peak; 0.5 mm. copper filter; 50 cm. target skin distance, and 10 by 10 cm. anterior and posterior fields.

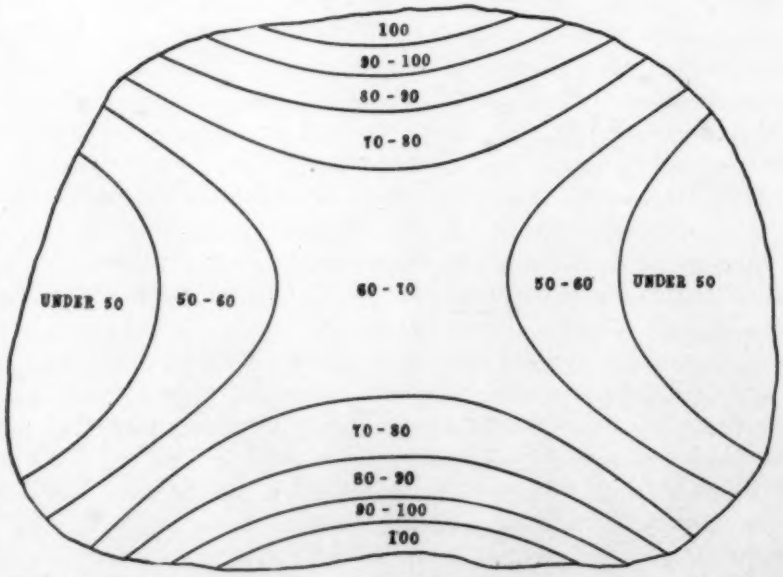


Fig. 8.—Cross-section of the body at the level of the pylorus showing the distribution of radiation from a radium element pack. A filter equivalent to 2 mm. of lead is used. The anterior and posterior fields are irradiated at a skin distance of 15 cm.

A great deal of information is now available as to the best method of delivering the desired dose by means of interstitial irradiation.[30] It is necessary to take into account the type of sources to be used and the size and shape of the lesion. Sources may be permanent radon seeds, removable radium or radon seeds or removable radium or radon needles of various lengths. As far as the radiation emitted by these various implants is concerned, there is little choice. The beta and gamma rays from radium and radon are identical. Filtration should always be at least 0.25 mm. of gold or platinum or its equivalent; beyond this, increase is not important. For globular or disk-shaped lesions it is probably easier to get fairly uniform irradiation by means of seeds; for elongated or infiltrating growths long needles may be preferable. At the Memorial Hospital interstitial irradiation for gastric

TABLE 1.—*Millicuries in Gold Seeds Required to Deliver Specified Doses to Masses of Various Diameters*

	Diameter of Mass, Cm.											
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0	7.0	8.0
Skin Erythema Doses	Number of Millicuries											
1	0.2	0.5	0.8	1.5	2.0	2.4	2.9	3.4	4.0	5.4	7.0	9.0
2	0.4	1.0	1.6	3.0	4.0	4.8	5.8	6.8	8.0	11	14	18
3	0.6	1.5	2.4	4.5	6.0	7.2	8.7	10	12	16	21	27
4	0.8	2.0	3.2	6.0	8.0	9.6	12	14	16	22	28	36
5	1.0	2.5	4.0	7.5	10	12	14	17	20	27	35	45
6	1.2	3.0	4.8	9.0	12	14	17	20	24	32	42	54
7	1.4	3.5	5.6	10	14	17	20	24	28	38	49	63
8	1.6	4.0	6.4	12	16	19	23	27	32	43	56	72
9	1.8	4.5	7.2	14	18	22	26	31	36	49	63	81
10	2.0	5.0	8.0	15	20	24	29	34	40	54	70	90
11	2.2	5.5	8.8	17	22	26	32	37	44	59	77	99
12	2.4	6.0	9.6	18	24	29	35	41	48	65	84	108
13	2.6	6.5	10	20	26	31	38	44	52	70	91	117
14	2.8	7.0	12	21	28	34	41	48	56	76	98	126
15	3.0	7.5	13	23	30	36	44	51	60	81	105	135

carcinoma has been carried out with gold radon seeds. For purposes of calculating the dosage, the lesions are considered as spheres or groups of spheres. Table 1 shows the amount of radon necessary to deliver specified doses within masses of given sizes or, conversely, the tissue doses resulting from the implantation of certain quantities of radon. The doses given are the minimum delivered within the specified volume, when the seeds are uniformly distributed within the inner half of the radius of the specified sphere.

It should be mentioned that any attempt to irradiate adequately a very large mass by interstitial sources may necessitate the use of more radiation than will be tolerated by the organism as a whole. The amount which can be thus tolerated is a matter for clinical determination.

30. Quimby, E. H.: The Intensity of Radiation in the Vicinity of Filtered Radon Implants, Radiology **10**:365, 1928.

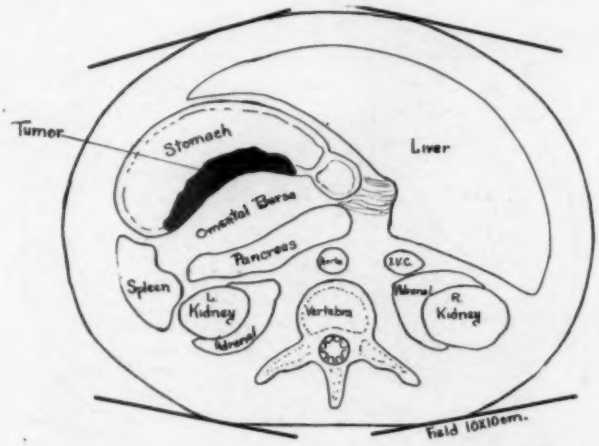
EXTERNAL IRRADIATION OF GASTRIC CANCER

The effectiveness of external irradiation depends not only on the degree of radiosensitivity of the gastric cancer but also on the depth dose or tissue dose delivered to the tumor within a certain time. The depth dose is modified by certain factors, as we have already explained, such as the source of radiation (200 kilovolt roentgen rays, 700 kilovolt roentgen rays and gamma rays from a radium element pack), the thickness and quality of the filter, the target skin distance and the target tumor distance. If all the factors of treatment are equal, it is seen that the dose delivered must vary according to the size of the patient, i. e., his body thickness. The estimation of this dosage is aided by a correct measurement with calipers of each patient while he is in the recumbent posture. The lateral and anteroposterior diameters of the body at the level of the epigastrium are recorded. Representative cross-section charts of the body at all the levels of the stomach are available and may be projected to a size comparable with each patient's measurements. The exact location and approximate size of the carcinoma are drawn on these topographic outlines, so that the computation of depth dosage may be done graphically and accurately (figs. 9, 10 and 11).

All external irradiation is given while the patient is recumbent in the lateral, prone or supine position. Prior to the institution of treatment, fluoroscopy after ingestion of a barium meal is done in each of these three positions in order that the exact position of the tumor might be projected and recorded in indelible ink on the patient's skin. The skin portals for irradiation are centered over these markings so that the beams of radiation are properly directed to cross-fire at the tumor. Four ports, right and left anterior and posterior, have been used for carcinomas in the distal segment of the stomach, but since we have found that nearly all our satisfactory therapeutic results are for carcinomas of the cardia and the fundus we seldom have occasion to employ these fields. Carcinomas of the proximal segment of the stomach are treated through three ports in the upper left quadrant of the abdomen (anterior, lateral and posterior) unless the patient is obese, when as many as five ports may be used to circumirradiate the left half of the abdomen. These ports measure 12 by 14 cm. or more.

The different modalities employed for external irradiation may be briefly described. We have found it worth while to apply the 200 kilovolt roentgen rays at a distance of 70 cm. rather than at 50 cm., although this set-up requires twice the time of irradiation to deliver the same dose to the skin. The increased time of each treatment is an advantage in our opinion, and, furthermore, the depth dose reaching the tumor is slightly increased. The filter commonly used is 0.5 mm. copper and 2 mm. aluminum. The depth dose is augmented considerably by

increasing the target skin distance to 150 cm., which we have done in several instances, with notable results in two cases (case 3). The roentgen exposure necessary to deliver a specified dose at this distance is nine times as long as with a target skin distance of 50 cm. We have used circular anterior and posterior skin ports at this distance measuring 27 cm. in diameter.



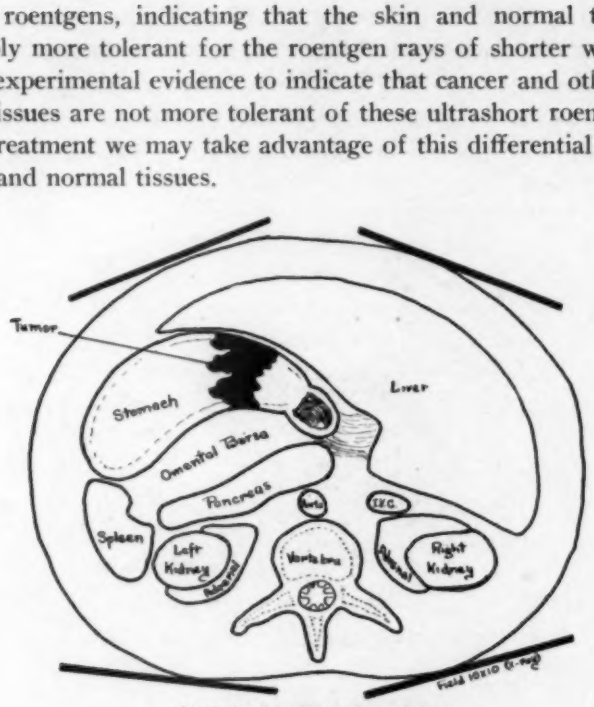
HIGH VOLTAGE X-RAY

Region	Dose to Skin Total "r"	Dose to Skin T.E.D.	Dose to Tumor Tumor Depth	Dose to Tumor T.E.D.
Left Lateral Ant.	840	1.4	55	0.7
" " Post.	840	1.4	35	0.5
Right " Post.	840	1.4	20	0.3
" " Ant.	840	1.4	25	0.3
Stomach Ant.	1000	1.7	30	0.5
Stomach Post.	500	0.8	50	0.4
Total Threshold Erythema Doses = 2.7				

Fig. 9.—Cross-section measurement of a patient with gastric cancer, illustrating the computation of depth dosage of radiation.

We have treated some patients with the General Electric 700 kilovolt x-ray machine, using a distance of 60 cm. and a filter equivalent to 5 mm. of copper. The depth dose with this set-up is not quite as great as that obtained with the 200 kilovolt x-ray machine at a distance of 150 cm., but the roentgen rays are of shorter wavelength because of the heavier filter. The threshold erythema dose for the 700 kilovolt roentgen rays with 5 mm. copper filter is 700 roentgens, whereas for the 200 kilovolt roentgen rays with 0.5 mm. copper plus 2 mm. aluminum

it is 525 roentgens, indicating that the skin and normal tissues are considerably more tolerant for the roentgen rays of shorter wavelength. We have experimental evidence to indicate that cancer and other rapidly growing tissues are not more tolerant of these ultrashort roentgen rays; hence in treatment we may take advantage of this differential sensitivity of tumor and normal tissues.



HIGH VOLTAGE X-RAY

Region	Dosage to Skin "Total"	T.E.D.	Dosage to Tumor % at Depth	T.E.D.	
L. Abd. Ant.	762	1.3	30	0.4	
L. " Post.	762	1.3	15	0.2	
R. " Post.	762	1.3	60	0.8	
R. " Ant.	762	1.3	25	0.3	Total 1.7

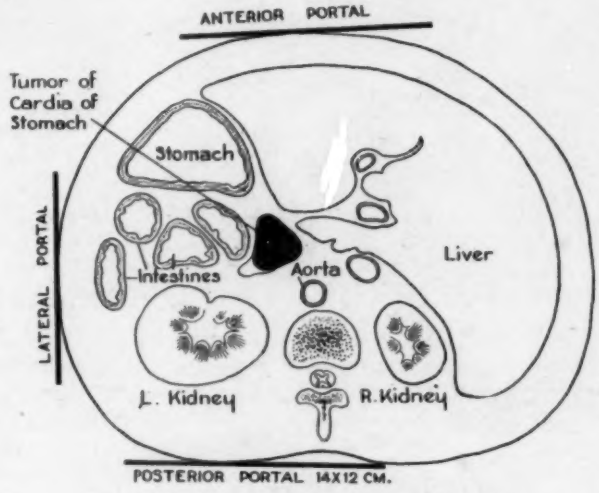
RADIUM ELEMENT PACK

Region	Mg-hrs.	T.E.D.	% at Depth	T.E.D.	
Abdomen Ant.	75,000	1.25	50	0.6	
" Post.	75,000	1.25	25	0.4	Total 1.0
Total to Tumor by all radiation = 2.7 T.E.D.					

Fig. 10.—Cross-section measurement of a patient with gastric cancer, illustrating the computation of depth dosage of radiation.

The first patients treated were given doses of from 750 to 800 roentgens to each skin portal, with a repetition of this intensive cycle in from ten to twelve weeks. The tissue dose administered to the tumors by this technic was inconsiderable. The present system of roentgen therapy depends on the daily administration of only from 300 to 350 roentgens to one skin port, alternating on subsequent days with treatments of similar dosage to the other ports, until each area of skin

receives a total of 3,000 roentgens. The daily fractionated treatments therefore consume the better part of a month for their completion. Coutard first advocated this principle in the treatment of cancer of the pharynx and larynx, and it has since proved its worth in cases of cancer of the breast and uterus. The patients are better able to tolerate these smaller daily treatments, and the tissue dose to the tumor is greatly augmented.



HIGH VOLTAGE X-RADIATION

Region	Dose to skin Total r"	T.E.D.	Dose to tumor % at depth	T.E.D.
Stomach Ant.	3000	5.4	35	1.89
" Lat.	3000	5.4	25	1.35
" Post.	3000	5.4	35	1.89
Total Threshold Erythema Doses				5.13

INTERSTITIAL RADON GOLD SEED

Region	Number of seed	Total mc.	T.E.D.
Tumor of Cardia	22	30	5
Total T.E.D. to Tumor = 10			

Fig. 11.—Cross-section measurement of a patient with gastric cancer, illustrating the computation of depth dosage of radiation.

Our 4 Gm. radium element pack has proved to be our most effective external applicator, although certain factors in treatment, such as the skin distance and the time of irradiation, are not altogether satisfactory. The filter is 0.3 mm. of platinum and 1.5 mm. of brass. The skin distance is 15 cm., and the dose at this distance is from 80,000 to 100,000 milligram hours (from 80 to 100 gram hours). Each daily treatment consists of two hours' exposure so that from twenty to thirty days in

all are required to complete the cycle of irradiation. We have the distinct clinical impression that with tissue doses of comparable degree the radium element pack is superior to our other modes of external irradiation (fig. 12).

Isodosis curves have been prepared with the use of water phantoms and cadavers; the depth dose actually delivered to the gastric cancer may be estimated from these curves. This dose is expressed in terms of threshold erythema units. We have been able to deliver from three

TABLE 2.—*Comparison of Depth Doses Delivered by Three Sources of Radiation*

	Settings in Use at Present									
	200 Kv. X-Rays 50 Cm. Distance 0.5 Mm. Cu. and 2 Mm. Al.				700 Kv. X-Rays 60 Cm. Distance 5 Mm. Cu.				Gamma Rays	
									10 Cm.	15 Cm.
Depth, Cm.	50 Sq.Cm.	100 Sq.Cm.	200 Sq.Cm.	400 Sq.Cm.	50 Sq.Cm.	100 Sq.Cm.	200 Sq.Cm.	400 Sq.Cm.	100 Sq.Cm.	150 Sq.Cm.
0	100	100	100	100	100	100	100	100	100	100
2	77	82	84	85	78	82	85	86	67	76
5	49	54	57	60	53	58	63	66	40	51
10	21	25	28	31	26	30	34	38	20	29
15	8	10	12	14	13	16	19	22	14	17
T.E.D. Time	Minutes				Minutes				Hours	
Water	9.0	8.3	7.8	7.4	48	44	41	39	7.5	15
Air	65	60	56	53						

	Other Possible Settings					
	200 Kv. X-Rays (0.5 Mm. Cu., 100 Sq. Cm.)				Gamma Rays	
Depth, Cm.	70 Cm. Dist.	85 Cm. Dist.	100 Cm. Dist.	150 Cm. Dist.	20 Cm.	25 Cm.
0	100	100	100	100	100	100
2	84	85	85	87	81	83
5	56	58	59	62	58	63
10	27	29	30	32	35	40
15	11	12	13	14	22	26
T.E.D. Time	Minutes				Hours	
Water	16	24	33	75	26	44
Air	120 (2 hr.)	180 (3 hr.)	240 (4 hr.)	540 (9 hr.)		

to five threshold erythema doses to carcinomas of the stomach; however, this is quite below the lethal dose for the average radioresistant gastric cancer. From eight to ten threshold erythema doses (T. E. D.) are necessary to sterilize most carcinomas of the breast and oral cavity, which are on the average less radioresistant than cancers of the stomach.

Holfelder's plan of using a compression diaphragm to exclude the organs overlying the tumor by pressure and replacing with air as much as possible the distance between the target and the tumor has been given a brief trial. In principle, this procedure brings the skin in closer proximity to the tumor and accounts for a relatively greater depth dose to the tumor. The increased dose thus administered is only a small

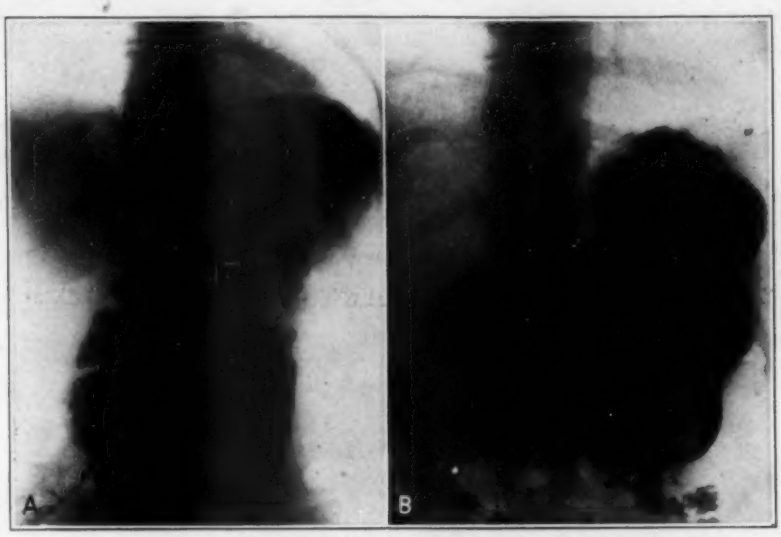


Fig. 12.—*A*, a roentgenogram of the stomach, showing a defect in the greater curvature of the fundus caused by a bulky papillary adenocarcinoma which could be palpated easily beneath the left costal margin. Metastasis had occurred to the left supraclavicular lymph nodes (signal node of Troisier). *B*, a roentgenogram of the same stomach fourteen months after external irradiation by a radium element pack. The patient gained 40 pounds in weight.

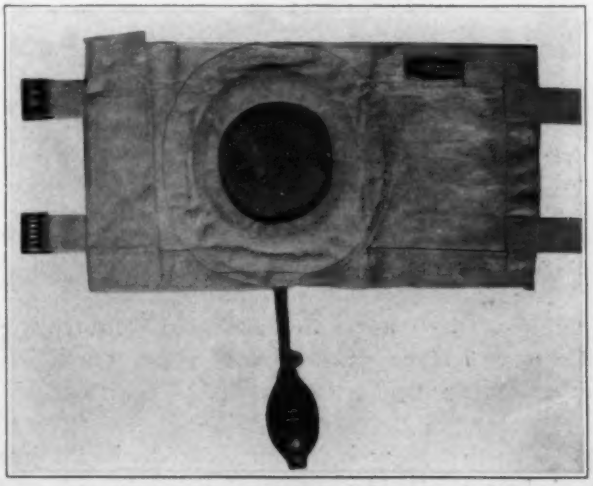


Fig. 13.—The compression belt for roentgenography or radiation therapy. The belt is snugly adjusted with the deflated rubber bag over the abdominal region of the tumor. Inflation brings the skin in closer proximity to the tumor.

fraction of one skin erythema dose and scarcely worth the effort (figs. 13 and 14). The same effect may be obtained by the use of pressure cones.

IRRADIATION OF THE BARIUM-FILLED STOMACH

Scholz [31] (1932) thought that the secondary rays in the region of the tumor might be intensified by irradiating the stomach when filled with barium, which not only would protect the adrenal glands by actual filtration but also would make possible sufficient irradiation with a low voltage roentgen ray source. The case reported was one of an inoperable carcinoma (according to the surgeon) which had been explored

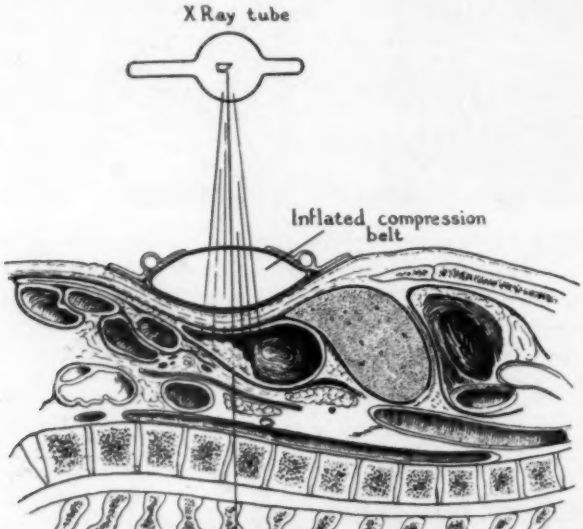


Fig. 14.—Sagittal section through the plane of a gastric cancer. An inflated compression belt is seen applied over the abdominal region of the cancer, bringing the surface of the skin nearer to the tumor. This procedure permits the delivery of a greater depth dosage of radiation to the carcinoma with equivalent erythema doses on the skin.

surgically and for which a gastro-enterostomy had been performed. The patient was well seven years after roentgen irradiation, having a normal stomach on roentgen examination. There was no biopsy of the tumor.

It seems to us that there is little rational basis for irradiation of the barium-filled stomach. The secondary rays produced by the contact of roentgen rays and barium are not deeply penetrating and therefore

31. Scholz, T.: Application of Roentgen Radiation to the Barium Filled Stomach, Radiology **18**:269, 1932.

would affect only the surface of the gastric cancer. This technic might be worth while only if the cancer could be thoroughly impregnated with a heavy metal or its salts. There is some conceivable detriment from the nonspecific action of the more caustic secondary rays on the noncancerous mucosa of the rest of the stomach. The only exception by which this principle might properly be applied is in the treatment of the diffuse superficial carcinomas, which are at first limited to the mucosal and submucosal layers. The difficulty here is that this type of gastric cancer is seldom diagnosed until metastases are evident, at which time this method of therapy would not be feasible. With our present technic of fractionated dosage, requiring daily treatments over three weeks, the patients would ingest a dangerously large amount of barium.

PREOPERATIVE IRRADIATION OF GASTRIC CANCER

We have not employed preoperative irradiation as a routine for cancers in the distal half of the stomach which we deem operable. There are several reasons for this decision. First, if the lesions are obstructive an operation is immediately necessary. Second, the radiation sickness and the disability for six weeks following intensive irradiation will be too great a handicap for subsequent surgical treatment. Third, it is necessary to wait until the cutaneous reaction to irradiation has subsided before proceeding with the operation. Fourth, preoperative external irradiation is of questionable value in the operable group because as a rule cancer in the distal half of the stomach does not fall in the radiosensitive variety, although lymphosarcoma occasionally occurs in this location. Whenever external irradiation precedes laparotomy, the dose must necessarily be moderate, else great difficulty is encountered in the healing of the wound. Severe radionecrosis of the abdominal wound has occurred three times in our experience, when we had occasion to perform two gastrostomies and one gastro-enterostomy, respectively, for inoperable gastric cancer which had been treated by prolonged roentgen irradiation in fractionated doses.

INTERVAL IRRADIATION WITH TWO STAGE RESECTION OF CARCINOMA OF THE STOMACH [32]

The majority of operable cancers situated in the distal half of the stomach can be removed safely by a one stage resection. Some operable gastric cancers occur in elderly patients on whom it may be dangerous to operate because of prolonged pyloric obstruction with its consequent starvation, dehydration and chronic sepsis. When partial pyloric obstruction becomes complete and acute, an emergency arises which

32. Pack, G. T.: Indications for Two-Stage Resection of Carcinoma of Stomach, S. Clin. North America **13**:517, 1933.

needs prompt surgical intervention. It seems best under such circumstances to relieve the immediate danger of continued pyloric obstruction by quickly performing a gastro-enterostomy, reserving the partial gastrectomy for cancer for a later date, when the water balance of the body is normal, the mineral content of the blood and tissues is restored, the glycogen reserve of the liver and muscles is reestablished and the organism is functioning more normally. The time elapsing between the two operations insures the establishment of good function in the gastro-enterostomy stoma and in the reestablishment of the gastrointestinal gradient. We have given roentgen treatments in the interval between the performance of gastro-enterostomy and resection, although we do not approve of this as a routine measure. If cautiously given it conceivably may retard the growth and dissemination of the cancer, but it is not curative. We mention this procedure because in one instance we found it possible to do a gastric resection twelve weeks after gastro-enterostomy had been done for a cancer of borderline operability, the patient in the meantime receiving an anterior and a posterior cycle of roentgen treatments.

CARCINOMA OF THE CARDIA AND FUNDUS

It has been our experience that the most radiosensitive gastric cancers are located in the cardia and the fundus. Such a cancer is usually inoperable because of its location, regardless of the extent of the growth; therefore, there has been little conflict in our decision to employ radium and roentgen rays in lieu of surgical intervention. The percentage of malignant tumors occurring in the cardia is reported in most statistics to be from 8 to 10, but at the Memorial Hospital 20 per cent of the gastric cancers have this regional localization, chiefly because it is an institute for cancer and receives many patients whose condition is deemed inoperable in general hospitals. Tumors in the cardia are more radiosensitive on the average than tumors situated in the distal half of the stomach; the fundal carcinomas constitute the most radiosensitive group of all, but are so relatively few that they do not alter perceptibly the average figures for radiosensitivity of gastric cancer. These cancers metastasize later and less widely than those of other locations in the stomach. The fundal carcinomas are bulky, papillary and vascular, which accounts for their satisfactory response to irradiation. The dangers of complications following irradiation of the cardia are less than in other parts of the stomach. This is particularly true with regard to interstitial irradiation, since the cardia is not in as close proximity to other important organs as is the pylorus and hence tolerates a relatively large dose of radium.

Use of Gastrostomy in Interstitial Irradiation.—A Janeway gastrostomy is often done preliminary to interstitial irradiation of cancer of the cardia. This operation constructs a hinged flap of the anterior gastric wall with the base at the greater curvature. The edges of the flap are then sutured to form a goose-neck, which is lined throughout by mucosa. The stoma of the goose-neck is sutured to a small incision in the skin under the left costal margin. This mucosa-lined tube leading into the gastric cavity insures the permanence of the gastrostomy. It serves the valuable purposes of relieving obstruction at the cardia, permitting the intake of sufficient liquid to prevent dehydration and enabling the physician to give the patient a diet of high caloric value which he cannot otherwise take through a persistently stenotic cardia. Moreover, it short-circuits the passage of food into the gastro-intestinal tract and relieves irritation of the cardia from food passing over it as well as from stagnation of food and liquids in the terminal portion of the esophagus. An even more important advantage of such a gastrostomy is the fact that it offers an opening through which direct visualization of the cardia is possible so that gold radon seeds may be implanted into the cancer.

This procedure is performed in the following manner: The gastrostomy stoma is gently enlarged with graduated French Hegar cervical dilators in order to permit the passage of an endoscopic instrument. A child's esophagoscope, cystoscope or bronchoscope can be passed through this stoma into the lumen of the stomach (fig. 15). The patient should not eat any food on the day this treatment is to be given, and it is well to lavage the stomach the night and the morning before this examination is carried out. Any residue of gastric juice found in the stomach is aspirated. After inflation of the stomach with air by means of a bulb attachment, the endoscope is introduced and passed to the cardia, making visualization of the cancer possible. The instrument successfully dilates the cardia and fundus of the stomach, thereby permitting the surgeon to implant gold radon seeds into the carcinoma through especially long hollow trocar needles. Extreme care must be taken not to perforate the stomach and to place the gold radon seeds at the proper distances from each other. The entire dose of radium is seldom given at one time because of the difficulty in exposing the entire tumor. Usually, two, three or four treatments are given in succeeding weeks. In addition to facilitating direct examination this exposure permits repeated removal of material for biopsy, thus enabling the operator to determine the degree of response of the tumor to interstitial radium therapy.

Surgical Exposure of the Cardia.—Interstitial irradiation of carcinoma of the cardia may be accomplished either from the mucosal side

through an esophagoscope introduced through a gastrostomy stoma or by direct implantation of gold radon seeds through the seromuscular coat. The latter method is feasible only with proper exposure of the cardia. We have used a modification of the Baudet and Navarro technic for exposing the cardia and fundus by the temporary resection of the left costochondral arch. An incision similar to the one designed by Marwedel is made, extending from the left sternal border in the region of the sixth left costal cartilage and carried downward until it runs parallel to and 1.5 cm. below the costal arch. The incision must be below the costal arch in order to leave sufficient musculature above for suture and closure, and it extends laterally as far as the anterior axillary line. The incision is made through the skin, fascia and muscles down to the plane of the costal cartilages and intercostal muscles. The last

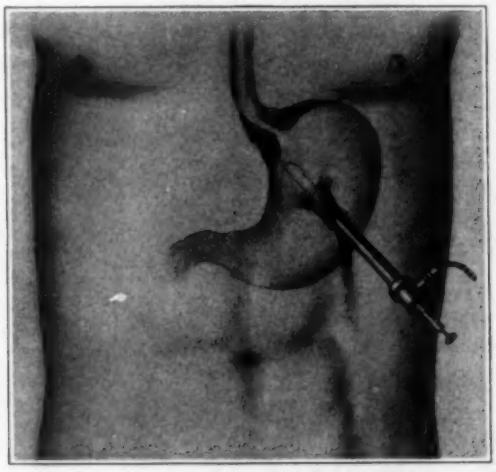


Fig. 15.—Interstitial irradiation of carcinoma of the cardia by the insertion of gold radon seeds through a Janeway gastrostomy. The implantation is done under direct visualization by using a bronchoscope, a cystoscope or a child's esophagoscope.

two ribs of the costochondral arch are severed at a distance of 1½ inches (3.8 cm.) from the border of the sternum. The last two or three ribs are severed laterally in the anterior axillary line (fig. 16). The line of incision through the ribs should be beveled to permit elevation of this flap. Elevation of this flap upward readily exposes the fundus, cardia, abdominal segment of the esophagus and left lobe of the liver.

The tumor is measured by calipers and the measurements recorded. A satisfactory caliper is the Williams outlet pelvimeter used in obstetrics. The dose of interstitial irradiation is computed so as to supplement the dose delivered from external sources. Gold radon seeds are then care-

fully introduced throughout the substance of the tumor. The trocar needles carrying the gold radon seeds are inserted at an acute angle to the gastric wall so that they penetrate the seromuscular coat obliquely; after traversing this coat for some distance the point of the needle dips inward into the substance of the tumor, where the gold seeds are dis-

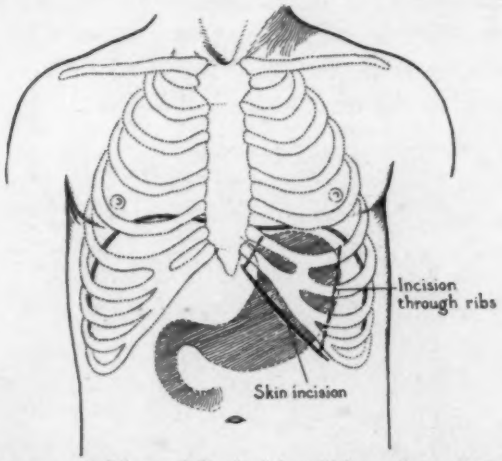


Fig. 16.—Diagram of Marwedel's incision below the costal margin and the Baudet and Navarro technic of elevation of the rib flap to expose the cardia.

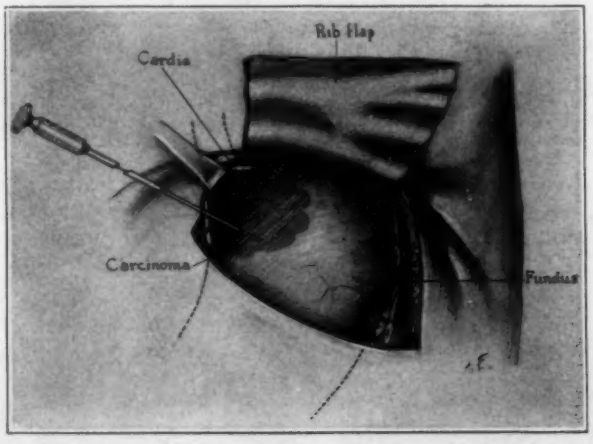


Fig. 17.—A drawing to show retraction of the superficial tissues upward, with elevation of the costochondral flap to expose the cardia. Interstitial irradiation of a carcinoma of the stomach is carried out by oblique insertion of gold radon seeds into the tumor.

lodged and remain. The passage of the needle along an oblique route through the gastric wall insures against the dangers of leakage and perforation (fig. 17).

The costochondral flap is replaced and sutured in position, although one may completely excise it with no deleterious results. If the flap is to be restored, sutures of kangaroo tendon are used at the junction of the cartilages and the ribs. The muscles which were severed transversely along the costal margin are united with mattress sutures. The fascia and skin are closed with interrupted sutures (fig. 18). This wound is subjected to unusually great stress and strain because of respiratory movements, and infection with suppuration is of more frequent occurrence than after the usual abdominal incision.

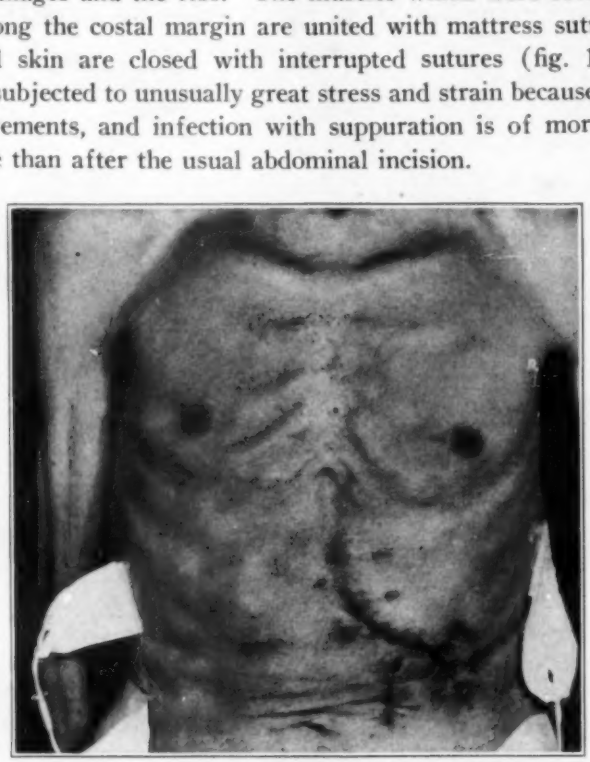


Fig. 18.—A recent incision for the Baudet and Navarro exposure of the cardia for the implantation of radium. At the same time a Janeway gastrostomy was done, the stoma of which is visible in the upper angle of the separate small wound.

IRRADIATION AFTER GASTRO-ENTEROSTOMY WITH EXCLUSION OF INOPERABLE CANCER OF THE PYLORUS AND ANTRUM [33]

Surgeons have found it expedient for radium therapy of carcinoma of the rectum occasionally to do a preliminary colostomy in order to short-circuit the contents. The advantages of this procedure are several; it keeps the rectal carcinoma clean, thus diminishing the degree of infection and the danger of complications, and at the same time affords relief from obstruction. The same principles may be applied

33. Pack, G. T., and Scharnagel, I. M.: Gastro-Enterostomy with Exclusion of Inoperable Cancer of the Pylorus and Antrum, J. A. M. A. **102**:1838 (June 2) 1934.

in the irradiation of cancer of the distal half of the stomach. If the tumors in this location are inoperable because of their fixation or metastasis to lymph nodes, etc., the procedure is to perform a preliminary gastro-jejunostomy, especially if obstruction is present and the roentgenograms show retention of the barium meal at the end of six hours. However, a simple gastro-enterostomy is usually not sufficient, because if food continues to come in contact with the pyloric or antral carcinoma the growth will be infected and irritated, thus producing bleeding, toxemia and cachexia. There is also danger of perforation after the interstitial use of radium. We have diminished these dangers by

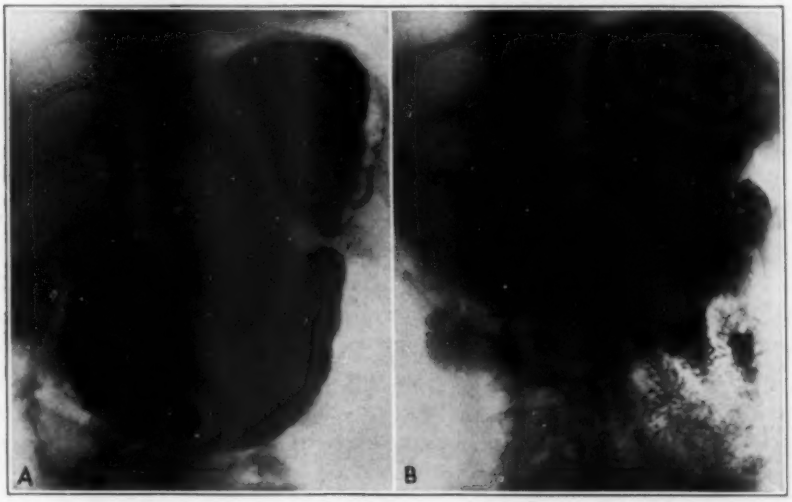


Fig. 19.—*A*, a roentgenogram of the stomach showing a defect caused by a carcinoma of the cardia. *B*, a roentgenogram of the same stomach made ten weeks after treatment by external and interstitial irradiation.

excluding the carcinomatous portion of the stomach from the proximal normal part.

This operation is performed as follows: In the gastrohepatic and gastrocolic ligaments are made openings that are only large enough to permit the introduction of two soft blades or the de Petz clamp. These blades are clamped proximal to the tumor, and the stomach is severed. The proximal and distal ends are closed by inverted continuous sutures. No attempt at resection is made; the procedure merely closes off the normal proximal part of the stomach from the distal carcinomatous portion. Then a simple posterior or, if necessary, anterior gastrojejunostomy is performed, the normal proximal segment being used. When the irritation subsides in the region of the tumor, the infection rapidly diminishes, bleeding lessens, the patient's appetite improves and he no longer has eructation of gas and foul liquids.

Furthermore, the danger of later occlusion of the gastro-enterostomy stoma by the cancer, if it was extensive when first seen, is prevented.

Two or more weeks after such a palliative operation has been successfully performed, a second small intermuscular incision is made directly over the tumor, usually with local anesthesia. Gold radon seeds in measured tissue doses are implanted in the isolated carcinoma through this exposure. The interstitial irradiation is supplemented by external irradiation, either the radium element pack or high voltage roentgen rays being used. We have not anchored the free carcinomatous segment to the anterior abdominal wall, although this has been suggested.

POSTOPERATIVE PROPHYLACTIC RADIATION THERAPY OF GASTRIC CANCER

Irradiation may be instituted within two weeks after an operation without danger of impairing the healing of the wound. We have not, however, employed postoperative radiation therapy as a routine procedure in cases of gastric cancer. In this setting, the decision as to the use of radium or roentgen treatment rests on a histologic analysis of the tumor. If it is of an anaplastic or diffuse radiosensitive variety, it is well to follow the gastric resection by a well planned cycle of high voltage roentgen treatments or by application of a radium element pack externally at a distance; under these circumstances we use a large field of irradiation. For the ordinary cancers of the stomach, such as the fibrocarcinomas, the malignant adenomas, the grade 2 adenocarcinomas and the gelatinous adenocarcinomas, postoperative prophylactic irradiation is not considered necessary, nor have we any evidence that it is worth while.

COMPLICATIONS

In addition to radiation sickness and occasional severe leukopenia, there are several other possible complications secondary to the irradiation of gastric cancer. The chief dangers of interstitial irradiation of gastric cancer are three: The needles for introducing the gold radon seeds into the stomach may perforate the wall and thus cause leakage of gastric contents and generalized peritonitis. We have not had this complication in any of the cases in which we have used this treatment. Hemorrhage is another danger, although it must be remembered that such accidents occur spontaneously in patients with carcinoma of the stomach who have had no treatment. Hemorrhage has followed external irradiation, particularly in cases of bulky papillary cancers in which necrosis and solution of the tumor occurred so rapidly that the blood vessels had not had time to become obliterated. In only one case did hemorrhage occur shortly after interstitial irradiation. This patient experienced a severe hemorrhage from a cancer of the cardia two days

after the introduction of four gold radon seeds containing a total of only 6 millicuries.

The last serious complication is late necrosis with ulceration and perforation either to the exterior or into some other abdominal viscus. This accident has happened once in our experience.

A 30 year old man was admitted to the Memorial Hospital with the signs and symptoms of a large advanced carcinoma of the cardia and fundus. When the cardia was exposed, the proximal half of the stomach was found to be occupied by a tumor 14 by 16 cm. in diameter, as large as an average-sized grapefruit. This tumor received a total of 55 millicuries of radon in thirty-seven gold radon seeds. The patient made an immediate uneventful recovery except for mild radiation sickness. Symptoms of a gastrocolic fistula developed six weeks after the interstitial irradiation had been given, and the patient died five days later. Postmortem examination revealed the establishment of a gastrocolic fistula. The colon had become adherent to the fundus, and ulceration of the necrotic tumor had produced an opening between the two organs. Microscopic examination of this enormous tumor showed almost complete destruction, with only a few carcinoma cells of questionable viability embedded in the scarred tumor base.

PATHOLOGIC CHANGES PRODUCED BY IRRADIATION IN CARCINOMA OF THE STOMACH

We have had little opportunity to study the pathologic changes induced in gastric cancer by external and interstitial irradiation, our specimens being limited chiefly to those obtained for biopsy (gastroscopic) or to those seen at occasional necropsies. In the latter case, death occurred at such intervals after irradiation that the residual or recurrent cancers had fully recovered from the effects of this treatment.

The varieties of gastric cancer are so numerous and the dosage and methods of treatment by roentgen rays and radium are so varied that we cannot relate the pathologic changes to any specific form of irradiation. The bulky adenocarcinomas are subject to spontaneous degenerative changes, such as infection, infarction and ulceration. Irradiation adds to this destruction, directly by influence on the cancer cell and indirectly by obliterative vascular changes. The rare papillary adenoma malignum is affected apparently by ischemia induced by thrombosis of the vessels in its stroma, whereas the medullary and diffuse cellular carcinomas seem to regress without noticeable alterations in the tumor bed.

External irradiation either by roentgen rays or by a radium element pack may produce some degree of arteritis with thrombosis, swelling of the collagen and hydropic and atrophic degeneration of cells with later lymphocytic infiltration. Interstitial irradiation in caustic doses causes coagulation necrosis accompanied by small intratumoral hemorrhages with later calcification. Foci of necrosis occur around the

embedded gold radon seeds. The adjacent serosa is covered by a plastic fibrinous exudate. Productive fibrosis, in some cases entombing inactive tumor cells, may be the end-result of proper treatment; necrosis, sloughing, hemorrhage or perforation, on the other hand, may follow too ambitious interstitial irradiation.

Fig. 20.—Photomicrograph of a section of a bulky adenocarcinoma of the stomach treated by interstitial radium therapy. There are coagulation necrosis and calcification of the tumor, with fibrosis of the bed of the tumor.

END-RESULTS

Approximately sixty inoperable gastric cancers have been treated. The majority were situated in the proximal half of the stomach. With the exception of one case, these experiments have been conducted during the last three years. One patient with gastric lymphosarcoma is living and well six years after radiation treatment. Another patient is in good health three years following irradiation of a carcinoma of the

stomach, and two others are without evidence of gastric cancer after an interval of two years. Palliative results are difficult to evaluate, but at least six patients have benefited greatly by these treatments only to succumb later to recurrent activity of residual cancer or to distant metastases. One middle-aged woman with a bulky carcinoma on the greater curvature of the fundus lived comfortably for twenty months and gained 45 pounds (20.4 Kg.) in weight; then generalized carcinomatosis developed, which caused her death three months later. A 40 year old man with a carcinoma occluding the cardiac orifice was able to engage in manual labor for one and one-half years following radiation therapy; he subsequently died of repeated gastric hemorrhages.

It seems self-evident from these results that radiation therapy, however administered, offers little hope for cure to the patient with gastric cancer. The justification for a trial of irradiation is the hope that the cancer may fall into the infrequent group of radiosensitive tumors, which must constitute less than 10 per cent of all gastric cancers. The occasional palliation is more frequent than the apparent cures, and it is this palliative result which has from time to time stimulated us to persist in the face of otherwise discouraging results and almost insurmountable technical difficulties. It would be unfair to compare these results with those of surgical treatment because only inoperable cancers are selected for radiation therapy. Whatever advantages or benefits have occurred to any of these sixty treated patients are over and above what could have been given them by surgical measures, by the very definition of the term inoperable. Radiation therapy is not proposed as a substitute for surgical treatment of operable gastric cancer.

SUMMARY

1. Gastric cancer was the first type of tumor ever treated by roentgen rays.

2. The disadvantages of irradiation of gastric cancer are: (*a*) the daily utilization of the stomach in feeding, (*b*) the inaccessibility of the stomach and the consequent low tissue dose delivered by external irradiation, (*c*) the danger of laparotomy for interstitial irradiation, (*d*) the degree of radiation sickness following treatment, (*e*) the extent of the cancer, as only inoperable gastric cancers are treated by irradiation, and (*f*) the frequent obstruction of the cardia and pylorus by these cancers.

3. Less than 10 per cent of gastric cancers exhibit any considerable degree of radiosensitivity. These rare radiosensitive cancers are usually situated in the cardia and fundus or on the greater curvature of the stomach.

4. There is a certain anaplastic small cell gastric cancer which bears a close morphologic resemblance to lymphosarcoma and is sensitive to radiation.

5. Gastric cancers have been treated by roentgen rays, radium element pack, interstitially implanted radium and combinations of these agents. The tissue dose delivered to the tumor in each case has been determined and expressed as skin erythema units. External irradiation is given through several ports to cross-fire at the stomach; the Coutard technic of fractionated dosage is the procedure of choice. The radium element pack is the most effective agent for external irradiation of gastric cancer.

6. We believe that there is little rational basis for irradiation of the barium-filled stomach. Several reasons are given that preoperative irradiation of resectable gastric cancer is not advisable. Interval irradiation with two stage resection of carcinoma of the stomach has been employed for cancers of borderline operability situated in the distal segment.

7. Carcinomas of the cardia have been treated by the implantation of gold radon seeds in addition to external irradiation. The radon seeds are implanted through an endoscope inserted in an opening made by gastrostomy as well as through the seromuscular coat, after exposure of the cardia by resection or elevation of a left costochondral rib flap.

8. Inoperable pyloric and antral carcinomas are treated whenever possible by irradiation after gastro-enterostomy with exclusion of the cancerous distal segment of the stomach.

9. Postoperative prophylactic radiation therapy is reserved only for those operable gastric carcinomas which on histologic analysis are shown to be among the rare anaplastic radiosensitive tumors.

10. The possible complications of irradiation of gastric cancer are (*a*) radiation sickness, (*b*) peritonitis, (*c*) gastric hemorrhage and (*d*) necrosis and the formation of fistulas with adjacent viscera.

11. Radiation therapy is a palliative rather than a curative measure for gastric cancer.

REPORT OF CASES

CASE 1.—A. E., a married white woman aged 46, applied to the Memorial Hospital for treatment on Jan. 2, 1929. She first complained of dysphagia and epigastric pain in January 1928. These symptoms increased in severity until May 1928, at which time roentgenograms of the gastro-intestinal tract showed a bulky tumor involving the cardia and the pars media. The diagnosis was confirmed at operation; a biopsy specimen was obtained from an inoperable tumor the size of a grapefruit. The tumor was composed of small hyperchromatic cells growing diffusely in a scant stroma with no tendency to form alveoli. Dr. Ewing and Dr. Stewart have been undecided whether to classify this tumor histologically as an anaplastic carcinoma or a lymphosarcoma but have leaned toward the latter diagnosis.

Treatment was entirely by irradiation, high voltage x-rays being employed in San Francisco late in 1928 and treatment by the 4 Gm. radium element pack at the Memorial Hospital in January 1929. With the radium pack, 48,000 milligram hours were given at a distance of 15 cm. anteriorly and posteriorly to cross-fire at the stomach. The tissue dose delivered to the tumor by the roentgen treatments was one and one-fifth skin erythema dose; by the radium element pack, four-fifths of a skin erythema dose.

The patient improved rapidly, regained her appetite and good digestion and gained weight. Repeated roentgenographic examinations have failed to reveal any filling defects or abnormalities in the stomach. The last verbal report in June 1935 from the patient, who is now residing in California, was that she was in excellent health, with no symptoms referable to her stomach.

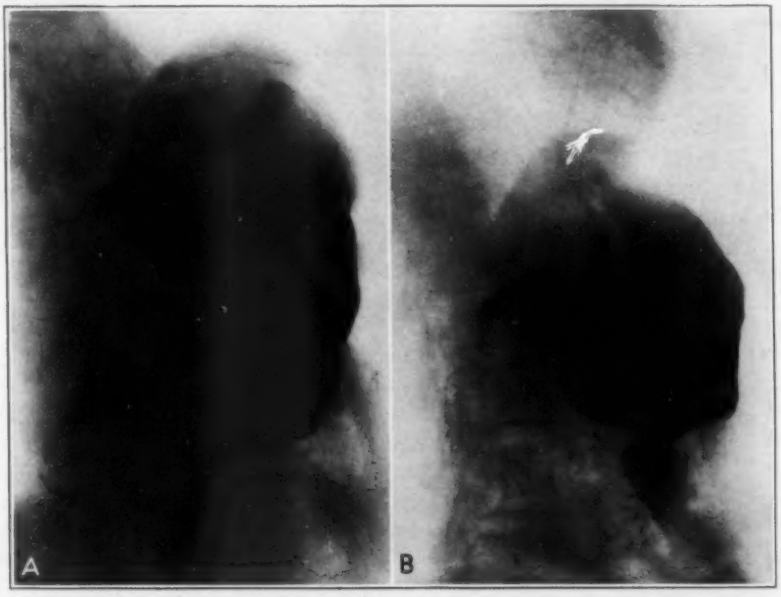


Fig. 21 (case 1).—*A*, a roentgenogram of the stomach showing a defect caused by an annular anaplastic small cell carcinoma of the antrum. *B*, a roentgenogram of the same stomach made three years after external irradiation by high voltage roentgen rays and a 4 Gm. radium element pack.

This patient has received seven years of life and good health following the successful irradiation of an inoperable primary gastric sarcoma.

CASE 2.—M. P., a Hungarian housewife aged 48, applied to the Memorial Hospital on Nov. 26, 1930, complaining of a tumor in the abdomen, of which she had been aware for three weeks. The gynecological, past and family histories were irrelevant.

The only noteworthy finding on physical examination was an abdominal tumor in the umbilical region, readily visible to inspection. It was well defined at its lower edge, which extended below the umbilicus. It had a smooth contour and firm consistence and moved with respiration. There was persistent absence of free hydrochloric acid after the administration of beta-iminazolyl-ethylamine hydro-

chloride. The blood count was normal in spite of apparent anemia. The Wassermann reaction was negative.

Roentgenograms of the stomach made on December 3, after the ingestion of barium revealed evidence of extensive involvement of the prepyloric segment, the appearance indicating carcinomatous infiltration of the gastric wall. There was 30 per cent retention of the barium meal at the end of six hours.

Permission to operate was refused; therefore on December 31, a cycle of high voltage roentgen irradiation was started, being delivered through four portals at intervals of from three to four days with a dose of 762 roentgens to each field. Starting on Feb. 9, 1931, and continuing over a period of six weeks, further external irradiation was administered with the 4 Gm. radium element pack at a skin distance of 15 cm., 75,000 milligram-hours being given anteriorly and the same dose posteriorly. The tissue dose delivered to the tumor by the roentgen treatments was one and seven-tenths skin erythema dose; by the radium element pack, one skin erythema dose, totaling two and seven-tenths skin erythema doses by both agents.

Roentgenographic studies of the stomach in November 1931 showed marked improvement with little evidence of involvement and no retention at the end of six hours. A third series of roentgenograms made in January 1933 showed no evidence of organic disease. Analysis of the gastric contents in April 1933 again showed persistent achlorhydria. The abdominal tumor has not been palpable for two and one-half years. The patient's weight is normal, and she has no symptoms referable to the gastro-intestinal tract. In April 1934 a third gastric analysis was made, revealing 70 degrees of free hydrochloric acid after the administration of beta-iminazolyl-ethylamine hydrochloride and the presence of occult blood in the gastric juice. Further roentgenographic studies, made in May 1934, showed a small deformity somewhat similar to that seen on the first films, taken three and one-half years before. The patient will not accept operative intervention.

Case 3.—S. P., a Jewish man aged 52, was admitted to the clinic for gastric diseases at the Memorial Hospital on Nov. 22, 1932. He was a painter who for a year and one-half had suffered from occasional attacks of nausea and vomiting and later from an aching and boring epigastric pain which was more severe after eating. The vomiting increased in frequency, and he had lost 19 pounds (8.6 Kg.) in weight.

Physical examination showed a poorly developed and undernourished man in poor general condition. His oral hygiene was poor. There was slight tenderness in the epigastric region but no palpable mass. The hemoglobin registered 50 per cent, and the red blood cells numbered 2,500,000 per cubic millimeter. Gastric analysis showed 80 degrees of free acidity in the specimen obtained when the patient was fasting and 92 degrees total acidity. The Wassermann reaction was negative. Roentgen examination of the stomach with a barium meal revealed an irregularity of the greater and lesser curvatures in the distal third of the stomach. There was a large residue of barium in the stomach after six hours. Because of the character of the pain and the high gastric acidity, the presence of a gastric ulcer was considered more likely than carcinoma. Yet the roentgenologists diagnosed the lesion as carcinomatous and pointed out that all ulcers on the greater curvature were invariably cancer. We recently had an opportunity to study a very malignant gastric cancer which was associated with hyperacidity.

The patient was advised to follow a modified Lenhartz diet with alkaline therapy and was warned of the danger of perforation. Thirteen days after the first observation he was admitted to the hospital because of severe epigastric pain. An emergency operation for a ruptured gastric ulcer was done; this revealed a bulky cancer involving the lesser and greater curvatures up to 3 finger-

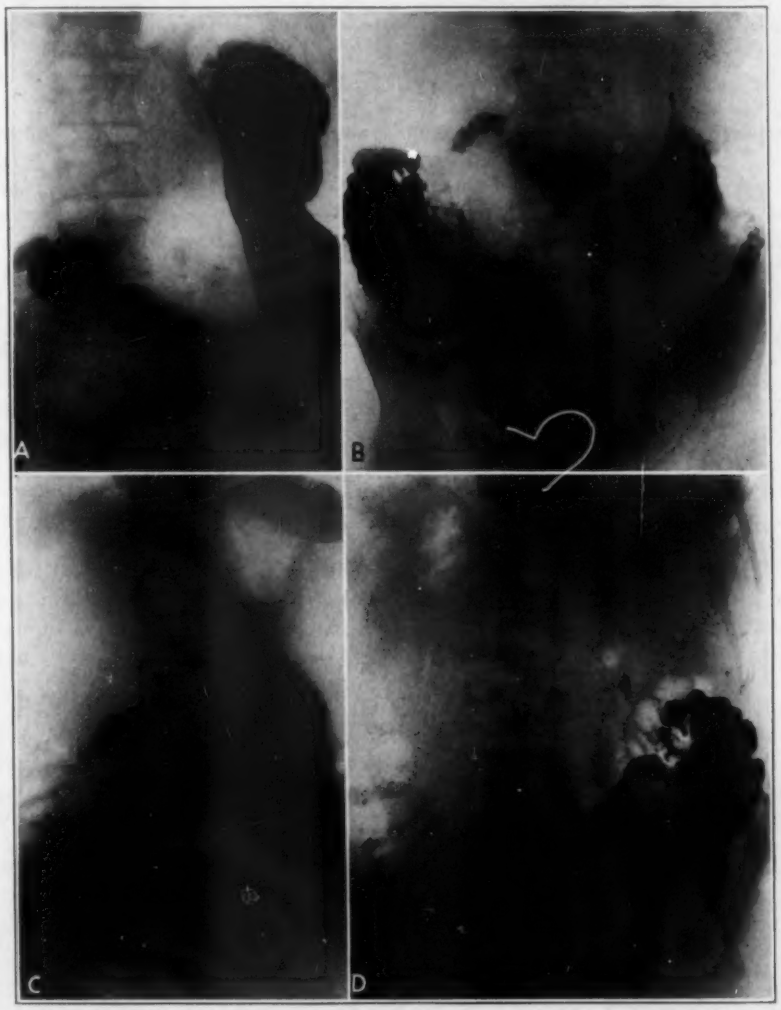


Fig. 22.—*A*, a roentgenogram of the stomach showing a carcinoma encircling the antrum and pylorus, causing stenosis of a moderate degree. *B*, a roentgenogram of the stomach six hours after a barium meal to show the degree of retention. *C*, a roentgenogram of the same stomach thirty months after intensive irradiation by a radium element pack. *D*, a roentgenogram of the stomach six hours after a barium meal to show the disappearance of the pyloric obstruction.

breadths from the cardia. The peritoneal cavity contained considerable gastric contents. A crevice 5 cm. long extended into the gastric lumen through the base

of the transverse mesocolon. The tissues were too friable to suture; so the great omentum was packed into the wound as a tampon and sutured in place. The abdomen was closed with drainage. A blood transfusion was given. The patient improved gradually after a stormy convalescence. Five weeks after the operative procedure he was able to receive roentgen irradiation to the entire abdomen given at a target skin distance of 150 cm. During two such cycles of therapy the palpable tumor and the marked ascites disappeared, and the patient gained 20 pounds (9.1 Kg.) in weight.

As the mass could be slightly palpated four months later, one cycle of high voltage roentgen radiation was given at a target skin distance of 70 cm., 1,200 roentgens being delivered in divided doses anteriorly and posteriorly. In December 1933 the patient was readmitted to the hospital, and an anterior gastroenterostomy with lateral entero-anastomosis was performed. A biopsy specimen taken at this time from the scarred fibrotic tumor showed gastric cancer in a state of abortive fibrosis. Additional roentgen irradiation followed this procedure, after which the patient again gained weight and his digestion became very good. He is in excellent health now, two years after the initial irradiation.

Case 4.—C. G., a Mexican man aged 67, began to suffer from postprandial epigastric pain, eructation of gas, anorexia, loss of weight and occasional vomiting in October 1932. Roentgenograms made in January 1933 with a barium meal showed a cascaded outline of the stomach with a deep persistent incisura on the greater curvature and a constant defect in the cardia. There was retention of a large amount of gastric residue after five hours. The diagnosis by three roentgenologists in as many hospitals for cancer was inoperable cancer of the stomach. Very small doses of high voltage roentgen irradiation given in January 1933 were followed by relief from symptoms and gain in weight.

In May 1933 no masses or tenderness were found by abdominal palpation, and the gastric contents one hour after the injection of beta-iminazolyl-ethylamine hydrochloride contained 56 degrees of free acidity expressed in terms of tenth-normal sodium hydroxide. All specimens of gastric juice still contained blood. Roentgen studies of the stomach at this time showed an hour-glass deformity with no retention after six hours. The Wassermann reaction was negative.

Further external irradiation was given through anterior, posterior and left lateral portals with the 4 Gm. radium pack at a skin distance of 15 cm. Eighty gram hours was given to each portal. Roentgenograms made following the reaction to this therapy showed decided improvement. The same treatment was repeated in December 1933. Some cicatricial contraction following this cycle is probably due to scar tissue. The patient has gained 25 pounds (11.3 Kg.) in weight and has no symptoms almost two years after the first irradiation.

FRACTURES OF THE BASE OF THE RADIUS IN ADULTS

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This study is based on a series of 155 cases of fracture of the base of the radius by indirect violence in 140 adults, observed in hospital and private practice and all personally examined by me.

As 10 per cent of all fractures [1] occur at the base of the radius and as the literature on the subject exhibits such diversity of opinion concerning etiology, pathologic process, treatment and end-results, this study was undertaken in 1926. It has been continued since then and includes cases of fracture occurring between the years 1913 and 1932.

The average length of time that elapsed between the fracture and the follow-up examination was sixteen months and the longest time nineteen years, while no case has been included in which the fracture had occurred less than three months prior to the follow-up examination.

Throughout this study an attempt has been made to correlate the anatomic with the cosmetic and functional results. To this end, the follow-up examination consisted of the taking of an adequate history, a thorough physical examination and roentgenograms of both wrists.

In the history, special note was made of subjective complaints, the length of time and the type of disability and the ability of the patient to resume his previous occupation.

The injured wrist was examined and compared with the sound one for bone deformities, local tenderness and limitation of motion. An anglometer was employed in the measurement of flexion and extension, while abduction, adduction, pronation and supination were compared with the normal motions in the opposite wrist and the results were recorded merely as an increase or decrease on the affected side. The circumference of each wrist and the radiocarpal articulation and the actual gripping power of each hand were measured and recorded. Attention was also paid to the range of motion of the fingers, the presence of injuries to the nerves and other soft tissue and the extent of arthritis, when present.

After the physical examination, roentgenograms were made of both wrists on the same plate. Both anteroposterior and lateral views were

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Read before the Section of Surgery of the New York Academy of Medicine, Dec. 1, 1932.

1. Adams, E.: The Symptoms and Treatment of Colles' Fracture, Internat. J. Surg. **24**:140, 1911.

made in each case. These were compared carefully with the films made at the time of reduction whenever the latter were available.

In the roentgenograms made at the follow-up examination particular attention was paid to the following points: (1) type of fracture, (2) comminution, (3) shortening of the radius, (4) widening of the wrist joint and the base of the radius, (5) spreading of the inferior radio-ulnar articulation, (6) tilting of the distal radial fragment and (7) fracture of the styloid process of the ulna and nonunion between it and the ulnar shaft.

MEASUREMENT OF BONE DEFORMITY

Simple methods were devised for actual measurement on the roentgenograms of the major bone deformities noted at the follow-up examination.

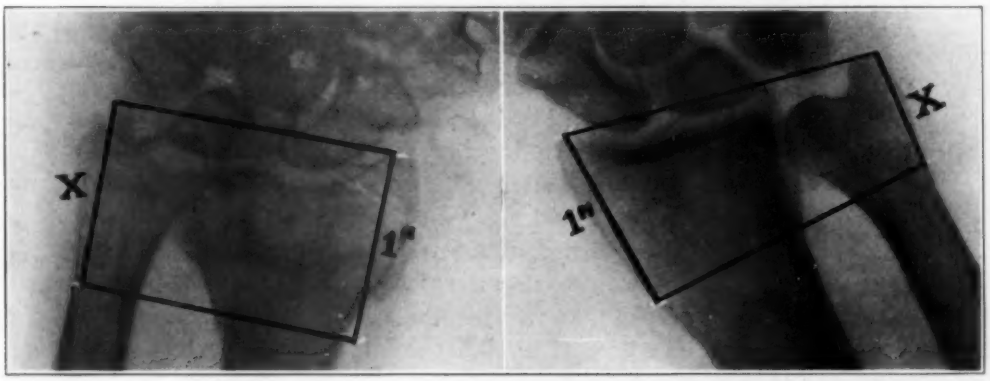

Fig. 1.—Diagram of the method of measuring the shortening of a radius.

Shortening of the Radius.—To measure shortening of the radius, a quadrilateral figure is constructed on the anteroposterior view of the roentgenogram of the sound wrist and a similar figure is constructed on the roentgenogram of the fractured wrist. A straight line is drawn from the tip of the styloid process of the radius to that of the ulna. A second straight line is drawn from the tip of the styloid process of the radius to a point 1 inch (2.5 cm.) proximal on its lateral border. From the proximal end of this line a third line is projected across both the radius and the ulna perpendicular to the long axis of the radius. The quadrilateral is completed by a fourth line, X, from the tip of the ulnar styloid process to the point where the third line crosses the medial border of the ulna. The difference between the X lines on the two quadrilaterals indicates the shortening of the fractured radius.

Widening of the Wrist Joint.—Using the anteroposterior view of each wrist, a line is drawn from the lateral border of the radius to the medial border of the ulna perpendicular to the long axis of the radius and at the level of the base of the ulnar styloid process. A comparison of these lines gives the amount of widening of the injured wrist joint. Similarly, widening of the base of the radius itself is determined.

Tilting of the Distal Radial Fragment.—Using the lateral view of each wrist, one straight line is drawn across the plane of the carpal articular surface of the radius, and another line is drawn parallel to the long axis of the radius. The difference between the angles, X, formed by the intersection of these lines on the two figures indicates the degree of tilting of the distal radial fragment in the fractured wrist. As the plane of the articular surface of the radius is normally tilted slightly forward, when this plane in the fractured wrist is level it may arbitrarily be considered as first degree posterior tilting; if just beyond a level plane, second degree, and if markedly tilted, third degree. Anterior tilting, when present, can be measured by the construction of the same kind of figure.

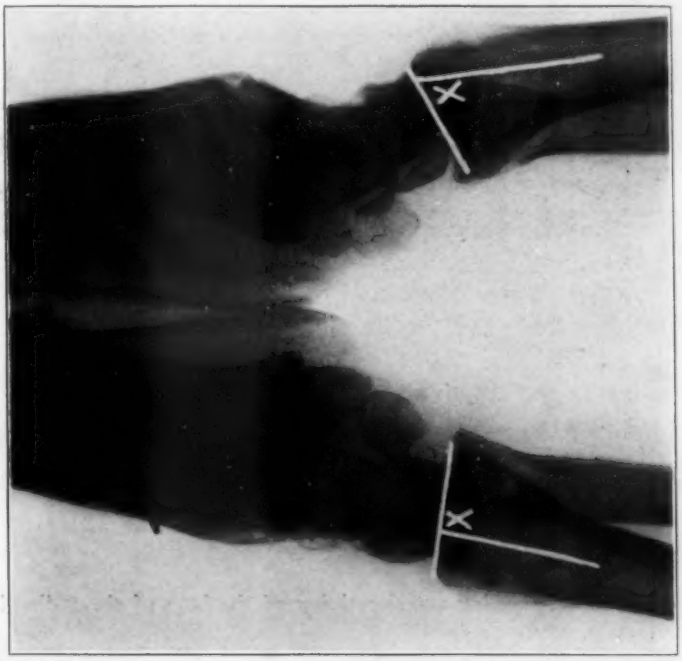

Fig. 2.—Diagram showing the angle of backward tilting at the base of the radius compared with the normal angle on the slide.

Anatomy.—For a better understanding of the etiology of these fractures it will be worth while to consider a few salient points in the anatomic structure of the wrist joint.[2] The carpal articulating surface of the radius is shallow, tilted forward and impressed with two fairly well defined grooves for contact with the scaphoid (navicular) and the semilunar (lunate) bones. On its medial aspect the base of the radius articulates with the ulna both directly and through the interarticular fibrocartilage. The cortex of the radial shaft, while fairly heavy at the

2. Morris, H.: Human Anatomy, ed. 5, Philadelphia, P. Blakiston's Son & Co., 1914.

base, becomes appreciably thinner at the site of the old epiphyseal line. Finally, the ligamentous attachments around the wrist joint are analogous to those about the ankle. There are three pairs of ligaments: (1) the radial and ulnar collateral ligaments, extending from the styloid processes to the carpal bones; (2) the anterior and posterior radio-carpal ligaments, (3) and the anterior and posterior radio-ulnar ligaments.

ETIOLOGY AND CLASSIFICATION

It seems advisable to consider the etiology of the aforementioned fractures in order more intelligently to classify and interpret the end-results noted.

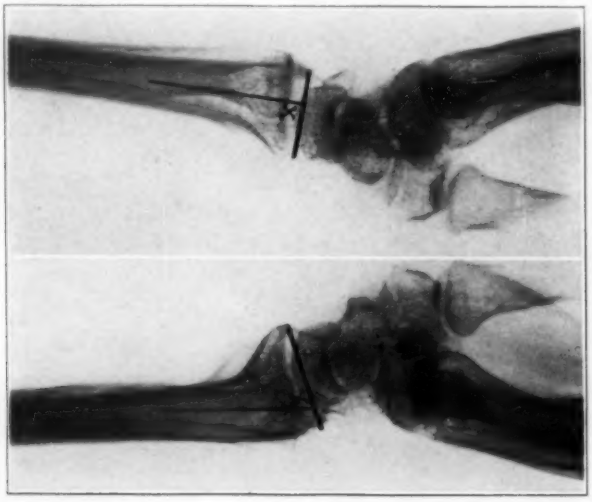

Fig. 3.—Diagram showing anterior tilting of the base of the radius in cases of overcorrection.

Fracture by indirect violence about a joint such as the wrist or ankle would necessarily be one of a few constant types, depending on the direction of the lines of force responsible for the fracture. The two factors principally involved may be called pull and push. Pull is the primary force and is exerted by the ligaments, while push is secondary and involves the pressure of bone against bone.

For instance, in a simple transverse fracture of the base of the radius the ligamentous pull causes the bone to break transversely and at a rather constant level. This has been described as arrachement. If the fracturing force is continued beyond this point to the pull, there is superadded a push, or pressure, against the distal radial fragment by the scaphoid and/or semilunar bone from below and by the proximal

radial fragment from above. The resultant fragmentation and extent of injury to the distal radial fragment will depend on the amount and direction of the push.

As man walks only on his lower extremities, nature provides a rear process or heel for the foot, so that fracture by indirect violence occurs in a lateral rather than in an anteroposterior plane. But the hand has no heel process, and therefore there is a tendency for fracture by indirect violence to occur in an anteroposterior plane and less frequently in a lateral plane.

On the theory, then, that fractures about the base of the radius by indirect violence in adults are dependent on the amount and direction of the force applied, there was evolved the following simple classification of such fractures, into some subdivision of which each of the 155 cases of this series seems naturally to fall:

I. Simple transverse fractures (arrachement [3])

II. Comminuted transverse fractures

- A. Extension or flexion force (scaphoid and semilunar),[4] Y or T types
- B. Abduction force (scaphoid)[5]
- C. Adduction force (semilunar)[5]
- D. Avulsion force (intermediary fragment,[6] styloid fracture [4])
- E. Lateral splitting force [7] due to the thrust of the proximal radial fragment into the distal radial fragment [8]

Simple Transverse Fractures.—It is well known that sufficient force exerted on the lower end of the radius through the ligaments about the wrist joint, as from a fall on the hyperextended hand, will result in a transverse fracture of the radius at a distance of from ½ to ¾ inch (1.2 to 1.9 cm.) proximal to its base. Jones [9] stated that as the dorsal lip of the carpal articular surface of the radius extends to a more distal level than the volar surface, it is bound to receive the full propulsive force of the carpus. It has been demonstrated by Pilcher [10]

3. Cotton, F. J.: Dislocations and Joint Fractures, ed. 2, Philadelphia, W. B. Saunders Co., 1924.

4. Cotton, F. J.: The Pathology of Fracture of the Lower Extremity of the Radius, Ann. Surg. **32**:194 and 388, 1900.

5. Gallois, E.: Fracture de l'extrèmité inférieure du radius: Étude radiographique, physiologique et expérimentale, Lyon, L. Bourgeon, 1898.

6. Kaufman, C.: Diagnose und Behandlung der subkutanen Radiusfraktur am Handgelenke, Deutsche Ztschr. f. Chir. **45**:531, 1897.

7. Hamilton, F. H.: Practical Treatise on Fractures and Dislocations, ed. 6, Philadelphia, Lea & Febiger, 1880, p. 305.

8. Bennett, E. H.: On the Rarer Forms of Fracture of the Carpal Extremity of the Radius, Tr. Roy. Acad. Med. Ireland **10**:322, 1891-1892.

9. Jones, R.: Analysis of One Hundred and Five Cases of Colles' Fracture, with a Few Remarks on Treatment, Liverpool M.-Chir. J. **5**:430, 1885.

10. Pilcher, L. S.: Fractures of the Lower Extremity or Base of Radius, Philadelphia, J. B. Lippincott Co., 1917.

and Speed [11] that the cross-strain causing the fracture is exerted at the ligamentous insertions just at or below the old epiphyseal line. There is a pulling apart of the anterior surface of the radius along a transverse line, while along a much wider area on the posterior surface there

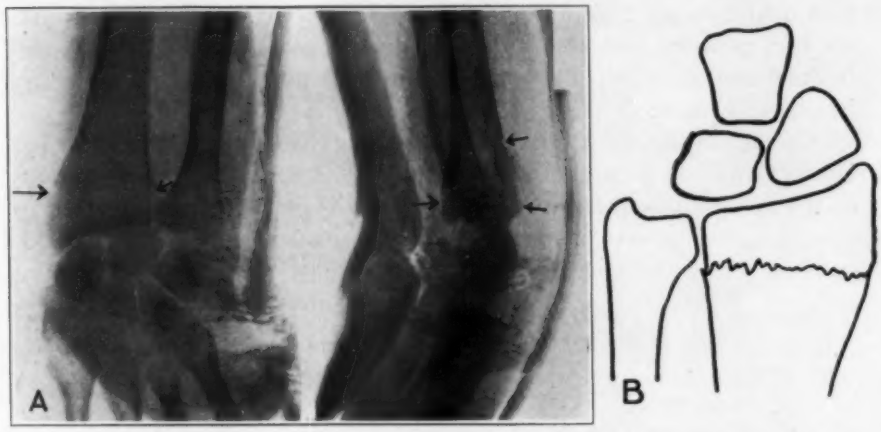

Fig. 4.—Roentgenogram (*A*) and diagram (*B*) of a simple fracture (arrachement), showing a simple fracture of the base of the radius, with the zone of bone injury plainly visible in *A*.

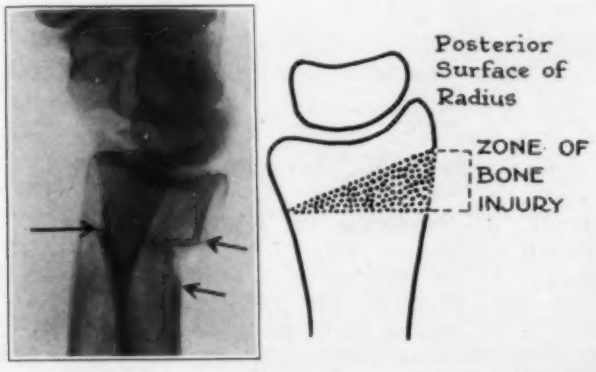

Fig. 5.—Lateral roentgen views before reduction, showing posterior crushing of the radius at the site of fracture and the extent of the zone of bone injury.

are compression and crushing of bone tissue. The result is a triangular area of bone injury, with the base of the triangle toward the dorsum of the radius. This may be termed the zone of bone injury.

11. Speed, K.: Traumatic Injuries of the Carpus, Including Colles' Fracture. New York, D. Appleton-Century Company, Inc., 1935.

According to Cotton,[4] shortening of the radius is due to the actual destruction of bone tissue, which is particularly likely to occur posteriorly. Such a zone can be demonstrated in the roentgenogram of practically every one of these fractures. The shape of this triangular zone of bony injury may be altered by the surgeon jamming the fragments into acute flexion, thereby causing more shortening by added injury to the anterior border of the fracture.

The fracturing force carries the hand and the distal fragment of the radius upward and backward. In addition, because the distal fragment of the radius usually remains attached to the ulna by the inferior radio-ulnar ligaments, the hand and this fragment are revolved into supination about the ulna as a pivot. Pilcher[10] spoke of this as supinating rotation. Knott[12] expressed the opinion that the triangular fibrocartilage acts as the radius of an arc through which the distal

Fig. 6.—Diagram showing alteration of the shape of the zone of bone injury by forceful flexion in reduction.

fragment of the radius rotates, the outer side of the latter describing a greater arc than the inner side.

Comminuted Transverse Fractures.—A. Extension or Flexion Force (Scaphoid and Semilunar): The os magnum (capitate) is the key bone of the carpus. Because of its strategic relation to the scaphoid (navicular) and semilunar (lunate) bones, it undoubtedly plays an important rôle in determining the type of comminution frequently observed in the distal fragment of the radius. On this Rotter[13] laid great stress. He has shown, with blocks, how the distal fragment is split into portions corresponding roughly to the articular facets of the scaphoid and semilunar bones by a force transmitted straight upward through the os magnum, thus producing a T or Y fracture.

12. Knott, J. F.: Colles' Fracture, M. Press & Circ. **31**:69, 89 and 111, 1881.

13. Rotter, H.: Ueber Frakturen des Radius am unteren Ende, Deutsche Ztschr. f. Chir. **156**:235, 1920.

B. Abduction Force (Scaphoid): With the hand in abduction, the os magnum is brought with greatest force against the scaphoid bone, and scaphoid fragmentation of the radius results.

Eliason [14] stated that the line of fracture depends on the position of the carpus and whether the force is transmitted through the thenar or the hypothenar eminence. Lucas [15] demonstrated these facts on dissected specimens.

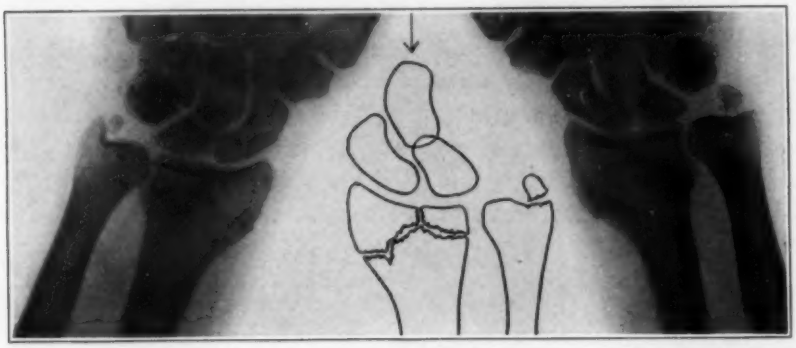

Fig. 7.—Roentgenogram and diagram showing the Y type of fracture (comminuted).

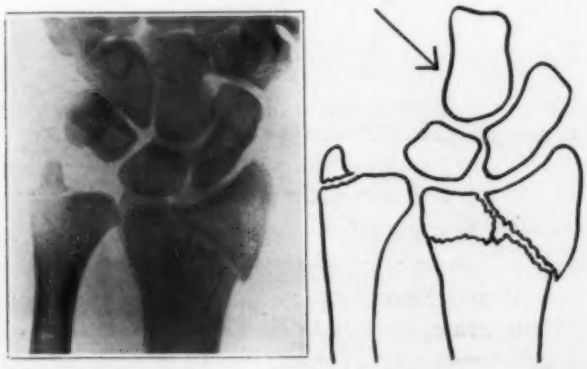

Fig. 8.—Roentgenogram and diagram showing the abduction type of comminution.

C. Adduction Force (Semilunar): Conversely, with the hand in adduction, the semilunar bone often breaks off a distinct fragment of the radius and may even fracture the end of the ulna.

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14. Eliason, E. L.: Fractures of the Humerus, Radius and Ulna, New York, D. Appleton & Company, 1925.

15. Lucas, R. C.: On Colles' Fracture, Guy's Hosp. Rep. **42**:375, 1883-1884.

D. Avulsion Force: In addition, in a large number of cases in the group of comminuted fractures I noted avulsion of a small intermediate fragment of bone by the inferior radio-ulnar ligament, analogous to the intermediate fragment of Tilleaux in fracture of the ankle. This type of fragmentation was mentioned by Kaufman,[6] Eliason [14] and Cotton,[4] who quoted the observations of Beidenhauser. The tendency of the

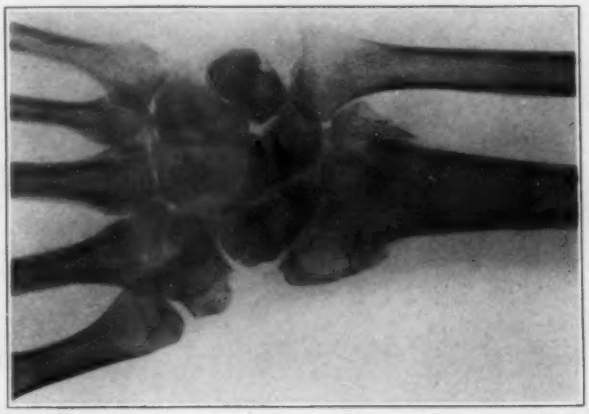

Fig. 9.—Roentgenogram and diagram showing the adduction type of comminution.

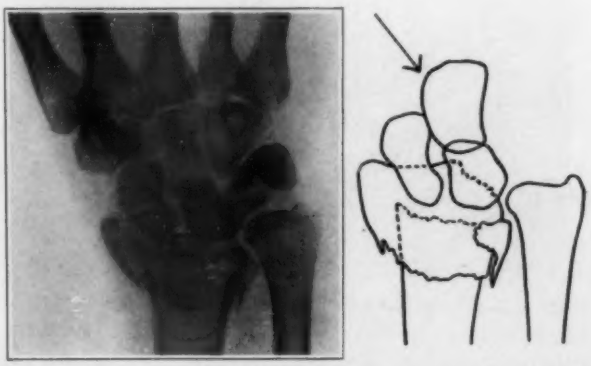

Fig. 10.—Roentgenogram showing tearing off of the intermediate fragment by avulsion force of the inferior radio-ulnar ligaments.

distal fragment of the radius to rotate into supination, already mentioned, doubtless acts as an additional avulsing force, as the fragment seems to be torn from one corner of the base of the radius.

Fracture of the styloid process of the ulna is due to avulsion by the ulnar collateral ligament as the carpal bones are suddenly carried away from it (fig. 8). There is no doubt that the inferior radio-ulnar

ligaments are occasionally torn apart,[7] as shown by permanent widening of that articulation in 26 cases of this series.

E. Lateral splitting of the distal fragment could actually be demonstrated in the lateral view of the roentgenogram in 63 cases. The result of this was usually a widening of the distal fragment in the lateral view.

ANALYSIS OF OBSERVATIONS ON CASES

Incidence According to Age.—It is well known that age is an important factor in these injuries, as has been reported by Hitzrot and Mur-

Fig. 11.—Roentgenograms showing widening of the inferior radio-ulnar joint caused by tearing of the ligaments.

Fig. 12.—Lateral roentgen view showing splitting of the distal fragment.

ray.[16] The youthful adult does not, as a general rule, sustain such extensive damage to the bones from a given trauma, and his convalescence is shorter than that of a person past 35. Also, the best results are obtained in youthful patients.

The average age in this series was 44 years. It will be seen in table 1 that the greatest number of cases occurred in persons between the ages of 40 and 60, and doubtless this is a fair representation of the

16. Hitzrot, J. M., and Murray, J. R.: The Factors That Influence the Prognosis in Fractures at the Base of the Radius, Am. J. Surg. **35**:17, 1921.

practice of any urban hospital in which there is no selection of emergency cases. It would tend to emphasize the importance of advancing age, with its accompanying impaired eyesight and the loss of sureness of foot, with consequent falls and injuries to bones that are older and more brittle. The rather high percentage in the decade from 20 to 30 probably represents increased activity in dangerous occupations, strenuous sports and the like.

Type of Fracture.—On the basis of etiology, the cases may be grouped in accordance with the classification presented elsewhere in this paper (table 2).

TABLE 1.—*Incidence According to Age in One Hundred and Forty Adults*

Age, Years	Number of Cases	Percentage of Total
20 to 30	28	19.5
30 to 40	20	14.2
40 to 50	34	24.2
50 to 60	33	23.5
60 or over	25	17.8

TABLE 2.—*Type of Fracture in One Hundred and Fifty-Five Cases* *

Classification	Number of Cases	Percentage of Total
1. Simple transverse fracture (no evidence of comminution)	45	29.0
2. Comminuted fracture		
A. Extension or flexion force (scaphoid and semilunar)	43	27.6
B. Abduction force (scaphoid)	17	10.9
C. Adduction force (semilunar)	13	8.3
D. Avulsion force		
Intermediate fragment	28	29.7
Styloid fracture	101	65.0
E. Lateral splitting force	63	40.6
3. Type not determined	37	23.7

* Fifteen of the 140 patients had a bilateral fracture.

The proportion of cases of simple transverse fracture is probably high, because many of the roentgenograms on which this study is based were made promptly after the fracture and reduction instead of two or three weeks later when, as has repeatedly been demonstrated, all lines of fracture stand out more clearly. It even happens that some lines which were not seen on the original films are plainly visible on those taken later, owing to absorption along the lines of fracture. So it is possible that in some of the cases the condition classed in table 2 as simple transverse fracture was in reality comminuted. In most of the cases in the "type not determined" group the fracture was, as a matter of fact, comminuted, but the type of the comminution was not discernible by roentgen study, the healing process having progressed so far as to obscure the original displacement of fragments.

Incidentally, the right wrist was injured in 59 cases, the left in 66 and both in 15. This is a matter of more or less academic interest, except that when both wrists were fractured there was usually a history of increased violence, such as a fall from a considerable height.

End-Results.—Of the 140 patients in this series 100 (71 per cent) had returned to, and were employed in, their previous occupation at the time of the follow-up examination; and 14 (10 per cent) were not working. In 26 cases (18 per cent) the fact whether or not the patient was working was not recorded. The average time out of work was from thirteen to fifteen weeks, the longest period being three years

TABLE 3.—*Reasons for Unemployment in Fourteen Cases*

Case	Time Out of Work, Weeks	Reason	Age, Years	Result on Examination
1	52	Inability	69	Marked deformity, with arthritis
2	24	Malingering	40	No arthritis, no marked deformity
3	72	Inability	57	Marked arthritis
4	24	Litigation	25	No arthritis
5	52	Inability	48	Marked arthritis
6	24	Inability	69	Marked arthritis
7	44	Litigation	42	No arthritis
8	24	Compensation	18	No deformity, no arthritis
9	32	Inability	60	Marked arthritis
10	156	Inability (?)	28	Deformity marked
11	24	Litigation	40	Slight arthritis
12	24	Inability	68	Arthritis marked
13	36	Malingering	25	No arthritis, no deformity
14	44	Litigation	57	Moderate arthritis

TABLE 4.—*Extent of Arthritis in One Hundred and Forty Patients*

Extent	Number of Cases	Percentage of Total
Marked	22	15
Moderate	38	27
Slight	14	10
Absent	45	32
Not mentioned	21	15

and the shortest four weeks. It is interesting to analyze the reasons given for unemployment in the cases of the 14 patients who had not returned to work (table 3). It will be seen that of the 14 patients not working over a long period of time 7 (50 per cent) were actually unable to work, while the remaining 50 per cent were affected by litigation or compensation.

Arthritis was recognized and recorded in 74 cases (approximately 53 per cent, table 4). In most cases in which arthritic changes were found at the follow-up examination, a tendency to generalized arthritis could be demonstrated. Such changes were most marked, as would be expected, in older persons. Injury to, and destruction of, the cartilage of the joint by the force of the fracturing blow was an important factor not alone in causing arthritis but in impeding convalescence and increas-

ing permanent disability. The finger joints,[17] especially the metacarpophalangeal joints, were most affected, and for this reason 11 patients in this series were unable to close their fingers completely.

Injuries to other soft tissues were in general noteworthy by their absence. In only 1 patient was there evidence of any kind of nerve impairment, in this instance, a numbness of the middle finger. There was no example of lasting injury to a blood vessel, and the tendons showed a decrease in function only in proportion to the presence of bony obstruction or arthritic changes.

Subjectively, more or less constant pain of varying degrees of severity was complained of by 41 patients, pain only during changes in the weather by 32, pain only on use by 12, stiffness by 21, weakness by 15 and deformity by 2. Tenderness, located most frequently over the ulnar styloid process was reported by 50 patients and was not noted by the remaining 90. Thirty patients had no complaints, and none were noted in the records of 6.

Fracture of the ulnar styloid process was demonstrated in 101 cases, or 72 per cent, as compared with the 54 per cent reported by Morton,[18] 42 per cent by Beck[19] and only 15 per cent by Braatz.[20] Nonunion was noted in 60 per cent of the cases of fracture of the ulnar styloid process. Grasby and Trick[21] reported nonunion in 50 per cent of their series, showing that in a high percentage of cases fracture of the ulnar styloid process results in nonunion. This probably accounts for the persistent pain and tenderness not infrequently complained of in this region.

That fracture of the intrinsic bones of the carpus as a complication in these cases is unusual is seen from the fact that it occurred in only 1 case (a scaphoid bone) in this series. Edwards and Clayton[22] also reported an incidence of only 1 case in a series of 155.

Open reduction for a serious persistent deformity was required in only 1 case.

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17. Le Breton, P.: Arthritis of the Joints of the Hand Following Colles' Fracture, Surg, Gynec. & Obst. **20**:450, 1915.

18. Morton, R.: A Radiographic Survey of One Hundred and Seventy Cases Clinically Diagnosed as Colles' Fracture, Lancet **1**:731, 1907.

19. Beck, C.: Fracture of the Carpal End of the Radius, with Fissure or Fracture of the Lower End of the Ulna and Other Associated Injuries, Ann. Surg. **34**:249, 1901.

20. Braatz, E.: Der Bruch des Radius am Handgelenk, Klin.-therap. Wchnschr. **21**:349 and 377, 1914.

21. Grasby, E. D., and Trick, S. P.: An Investigation of the End-Results of Colles' Fracture, Brit. M. J. **1**:391, 1929.

22. Edwards, H., and Clayton, E. B.: Fractures of the Lower End of the Radius in Adults (Colles' Fracture and Backfire Fracture), Brit. M. J. **1**:61, 1929.

Objectively, it is interesting to compare a few of the major defects resulting in these cases from the standpoint of anatomy, cosmesis and function. If the anatomic deformity and the cosmetic and functional results are reported in parallel columns, the close relationship between them is striking (table 5).

Since in 139 cases of fracture, or approximately 89 per cent, there was some disturbance in one or more of these groups, it is evident that perfect results following fractures of the wrist are indeed scarce. However, although permanent disability [23] in individual patients ranged from 10 to 90 per cent, the average was only 20 per cent.

TABLE 5.—*Anatomic, Cosmetic and Functional Results in One Hundred and Fifty-Five Cases*

Anatomic Defect	No. of Cases	Cosmetic Result	No. of Cases	Functional Result	No. of Cases
1. Shortening of the radius	122	1. (*a*) Radial deviation of the hand	120	1. (*a*) Increase in abduction	74
		(*b*) Prominence of the head of the ulna	117	(*b*) Decrease in adduction	72
2. Widening of the wrist joint	116	2. Widening of the wrist joint with increase in its circumference	116	2. (*a*) Decrease in supination	90
(*a*) Widening of the base of the radius	111			(*b*) Decrease in pronation	13
(*b*) Spreading of the inferior radio-ulnar joint	26				
(*c*) Intermediate fragment	28				
(*d*) Lateral splitting of the base of the radius*	106				
3. Tilting of the distal radial fragment	139	3. Angulation of the wrist	121	3. Decrease in gripping power and	112
(*a*) Posteriorly	118	(*a*) Silver fork deformity	110	(*a*) Increase in extension	94
				Decrease in flexion	113
(*b*) Anteriorly	21	(*b*) Flexion deformity	11	(*b*) Decrease in extension	6
				Increase in flexion	5

* The fracture lines were seen in the lateral roentgen view.

Shortening of the Radius: [24] This anatomic deformity was present in all but 33 cases of the series and averaged ⅙ inch (0.4 cm.). It is responsible for certain important cosmetic results, such as radial deviation of the hand and prominence of the distal end of the ulna (through leveling of the styloid processes), which in an extreme case give a rather hideous appearance to the extremity. To the same anatomic defect may be traced less important disturbances of function, occurring in abduction and adduction.

23. This is computed on the basis of anatomic, cosmetic and functional results.

24. Boorstein, S. W.: Rational Treatment of Fractures of the Lower End of the Radius, Am. J. Surg. **39**:50, 1925.

Widening of the Wrist Joint: Widening of the base of the radius, spreading of the inferior radio-ulnar articulation and the presence of intermediate fragments and lateral splits, with lateral widening of the base of the radius, are related anatomic deformities which may be grouped together as underlying that cosmetic result so frequently seen, a widened, thickened wrist.[24] They give rise as well to functional disturbances, interference with pronation and supination.

In textbooks and the current literature on these fractures one frequently encounters the statement that widening of the wrist is due to spreading of the inferior radio-ulnar articulation. Yet, in this series of 155 fractures, while widening of the wrist joint with a definite increase in its circumference occurred 116 times (74 per cent), perceptible widening (measurable in fractions of an inch) of the inferior radio-ulnar joint could be demonstrated in only 26 (17 per cent) cases.

Spreading of the inferior radio-ulnar articulation occurred most often in those fractures in which there was no comminution of the distal radial fragment and undoubtedly represented tearing of the inferior radio-ulnar ligaments. However, as the majority of fractures of the base of the radius are comminuted, there is much less likely to be tearing of these ligaments than spreading of the fragments and tearing off of a piece of bone by the ligaments. For example, in 28 cases an intermediate fragment could be demonstrated; apparently the inferior radio-ulnar ligaments had actually pulled off a piece of bone from the base of the radius.

Tilting of the Distal Radial Fragment: Posterior tilting of the first degree (on the basis of arbitrary standards already described) was found in 52 cases, of the second degree in 54 cases and of the third degree in 12 cases, making a total of 118 cases, or 76 per cent. In each case there was a silver fork deformity of some degree, with limitation of flexion and usually an increase of extension. Anterior tilting of the first degree was present in 15 cases, of the second degree in 5 cases and of the third degree in 1 case, making a total of 21 cases, or 14 per cent. In each of these there was a varying degree of flexion deformity, with a consequent limitation of extension and an increase of flexion (table 5). Loss of gripping power seemed to result with equal frequency from both anterior and posterior tilting. In 16 cases no tilting could be demonstrated.

TREATMENT

In 55 of the 155 cases of fracture the wrist was splinted in acute flexion; in 90, straight out or in slight flexion, and in only 10, in extension. In each case the wrist was held in ulnar deviation. Splints were of molded plaster, anterior and posterior, and were retained for an average of twenty-two days (Kaufman[6]).

In the majority of cases active motion of the wrist was commenced on the ninth day after reduction. In no case was passive motion employed. Motion of the fingers was encouraged from the outset. In 78 cases baking and massage were administered, and in 38 no baking and massage were given, while in 24 cases this treatment was not mentioned.

Treatment had best be considered with regard to immediate care and after-care. Immediate care has to do with reduction of the fracture, the position of the parts following reduction and the application of splints. After-care embraces the period of splinting, the institution of motion, the use of baking and massage and the return of the patient to his work.

Since, as has already been shown, poor functional and cosmetic results are the natural outcome of a faulty anatomic result,[25] the aim of treatment should be to correct and prevent anatomic deformities. This can best be accomplished, first, by gentle and proper manipulation at reduction,[6] with proper anatomic return to normal position and maintenance of that position by splints after reduction (Darrach [26]), and, second, by proper after-care of the fractured part during the period of convalescence, so that anatomic deformities do not increase or recur.

Immediate Care.—Reduction: It is generally agreed that these fractures should be reduced as soon as possible.[26] General anesthesia induced by nitrous oxide and oxygen is probably used most frequently. Local infiltration of 1 per cent procaine hydrochloride into the hematoma seems to be satisfactory in selected cases, but it was used only once in this series.

Reduction should be accomplished with the least possible trauma,[26] as each additional trauma along the line of fracture causes an increase in the extent of the zone of bone injury and hence increases the chance of anatomic deformity. Impaction should not be broken up roughly by rocking the fragments vigorously back and forth on each other. Neither should the fragments be jammed tightly into each other for the so-called reimpaction.

Molding of the fragments at the time of reduction is important. Lateral pressure exerted from both sides simultaneously, with pressure from the front and the back, will reduce the tendency of the distal radial fragment to mushroom and slip out of place. This is especially true when there is comminution.

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25. Lacroix, P. G., and Cohn, I.: Fractures of the Base of the Radius: Method of Treatment and End Results, New Orleans M. & S. J. **77**:425, 1925.

26. Darrach, W.: Fractures of the Lower Extremity of the Radius: Diagnosis and Treatment, J. A. M. A. **89**:1683 (Nov. 12) 1927.

Position of the Parts Following Reduction: The proper position in which to place the fractured parts seems clear enough if the underlying pathologic change is understood. As has been shown, in the usual fracture the zone of bone injury is triangular, with its base toward the dorsum of the wrist. Thus there is at the site of fracture a wedge of injured bone which must be absorbed and replaced by new bone and which may collapse if the hand is put in extension, causing a recurrence of the initial deformity. Further, it can be shown that jamming the hand down into acute flexion changes the shape of the zone of bone injury, increases the extent of bone injury, tends to increase radial shortening and may give rise to a permanent flexion deformity. Therefore, an intermediate position of slight flexion seems best, as advocated by Edwards and Clayton,[22] Ely [27] and Abbe.[28] The hand should then be carried into ulnar deviation to approximate the fragments of the ulnar styloid process (when it is fractured) and to take the pressure of the hand off the line of fracture. Rather marked supination is also favored, to guard against the loss of supination as well as to lessen the pull of the extensor muscle,[29] which tends to tip the distal fragment of the radius posteriorly. For example, with the hand in pronation and with the splints reaching only to the elbow there is a tendency for the biceps muscle to supinate the proximal fragment of the radius, union then occurring with the distal fragment in pronation and the proximal fragment in supination.

Splints: An anterior and a posterior molded plaster of paris splint should be used. They are easy to make, can be applied quickly and can be molded to the individual patient; besides, the wrist can better be held in its corrected position while the splints are being applied than during the application of circular plaster. Wood or metal splints cannot be molded to the patient as well as plaster. Subsequent increase or diminution in swelling of the soft parts can be accommodated merely by rebandaging the splints.

The anterior splint should reach distally to the crease in the palm of the hand, sometimes referred to as the head line, which indicates anteriorly the metacarpophalangeal joints. This splint should run proximally to just below the elbow joint. The posterior splint should begin at a distal level behind the knuckles and extend proximally above the elbow, in order to give good support to the hand and to the distal fragment of the radius, thus removing pressure from the line of fracture and preventing shortening. In this way, too, the fragments can be kept

27. Ely, L. W.: Colles' Fracture, with a New Theory of Its Mechanism, J. A. M. A. **50**:2130 (June 27) 1908.

28. Abbe, R.: Colles' Fracture, Internat. Clin. **4**:209, 1893.

29. Brown, A. J.: The Treatment of Colles' Fracture Considered from the Standpoint of Muscle Physiology, Am. J. Surg. **31**:122, 1917.

properly apposed in supination (Darrach). Free active motion of the finger joints, especially of the metacarpophalangeal joints, is thus assured.

After-Care.—Period of Splinting: It has been shown by Leriche [30] that the period of maximum absorption and brittleness in a knitting fracture is from the second to the third week. This may be termed the critical period, for clinically it is the time when complete redisplacement [31] is most likely to take place in those cases in which protection is insufficient. These fractures should therefore be protected by splints for a period of three weeks in patients 30 years of age or younger; in patients beyond that age four weeks should be adhered to as a period of protection against the recurrence of deformity. Edwards and Clayton,[22] Kaufman [6] and Adams [1] advised similar periods of protection by splints.

The Institution of Motion: Within the past ten years active and passive motion as early as forty-eight hours after reduction of fracture of the wrist has been advocated. But it is well to consider carefully the pathologic change underlying such injuries; any pressure on the line of fracture, especially during the critical period, will surely cause anatomic shortening and spreading of the comminuted fragments.

Lucas-Champonnière [32] is perhaps quoted most frequently on this point, yet in his original article the cases were carefully selected, and it was only in the case of the simplest fracture without displacement that he started motion as early as the second day. With a severely comminuted fracture he immobilized the wrist for a longer period without active motion. In all cases he exercised great caution in having the patient move the fractured part. There are undoubtedly a few selected cases in which motion at the wrist joint could be started as early as in forty-eight hours, but it is a much safer general rule to keep the joint immobile and protected for three weeks.

Motion of the fingers,[33] however, is another matter. Constant active motion from the outset is essential to a good result. It acts as a massage to the fingers, stimulating the circulation, maintaining the tone of the nerves and preserving the nutrition of the tissues. With regard to proper function, the metacarpophalangeal joints are the most important joints in the hand, and during the period of convalescence every effort

30. Leriche, R.: Physiology of Bone, St. Louis, C. V. Mosby Company, 1928, p. 139.

31. This took place in 6 cases of fracture in this series and is therefore an actual menace.

32. Lucas-Champonnière, J.: Thérapeutique des fractures de l'extrèmité inférieure du radius, J. de méd. et chir. prat. **79**:129, 1908.

33. Goretzky, P.: Ein Beitrag zur Behandlung der Radiusbrüche im unteren Drittel, Deutsche Ztschr. f. Chir. **205**:285, 1927.

should be made to preserve their flexibility. In the final analysis, the function of the fingers is the most important part of the end-result and should always be kept in mind.

The Use of Baking and Massage: After removal of the splints at the end of three or four weeks, baking and massage may be begun. But the value of this treatment is frequently overrated. Active motion is likely to be productive of much more satisfactory results. The baking and massage cause transient hyperemia and a feeling of well-being for several hours, after which the part becomes cold and the reaction of stiffness sets in. Constant active motion and slight use of the hand at this time give a continuous and more physiologic massage, normal function being restored much more quickly. The patients in this series who were treated by active motion alone seemed to recover more rapidly than those who received baking and massage, although no definite statistics can be given.

The Return of the Patient to Work: In this series the average time lost from work was thirteen and five-tenths weeks, which coincides closely with the experience of Eliason.[14] As a rule, approximately three months should elapse before a man returns to heavy manual labor. Light work, however, may be resumed in two months, usually with considerable benefit. All symptoms that are going to clear up, such as stiffness, pain and limited motion, usually disappear in the first twelve months. All symptoms persisting beyond this period should be considered permanent.

SUMMARY

A series of 155 cases of fracture of the base of the radius by indirect violence in 140 adults, all examined by me on an average of sixteen months after reduction, are analyzed as to etiology, pathologic change, treatment and end-results.

Shortening of the radius averaging ⅙ inch occurred in 78 per cent of the cases.

Widening of the wrist joint was seen in 75 per cent. In most cases it was due not to spreading of the inferior radio-ulnar articulation but to an actual increase in the width of the base of the radius.

Tilting of the distal radial fragment posteriorly occurred in 76 per cent of the cases, and anteriorly in 14 per cent, and comminution of this fragment was present in 68 per cent.

Fracture of the styloid process of the ulna was noted in 72 per cent, in 60 per cent of which nonunion was noted.

Fracture of the carpal bones was rare, 1 case only (of a scaphoid process) occurring in this series.

Permanent injury to soft tissues was practically nonexistent.

In 90 per cent of the cases there was evidence of some defect in the anatomic, cosmetic or functional results to greater or less degree.

Cosmetic and functional pathologic changes, when present, could always be traced directly to an underlying anatomic deformity.

The length of disability averaged three months, and most patients were able to return to their previous occupations.

The average permanent disability was approximately 20 per cent, ranging from 10 to 90 per cent in individual cases.

A simple and reasonably accurate method of roentgen measurement of anatomic deformities resulting from these fractures has been devised and is herewith presented.

A short and convenient classification of such fractures is suggested, based on the direction of the lines of fracturing force.

CONCLUSIONS

1. In cases of fracture of the base of the radius by indirect violence in adults, the manner of reduction and the position in which the fragments are to be held after reduction should be determined only after careful study of the pathologic changes in the bone, as shown by the roentgenogram in each individual case. This should include (*a*) consideration of the zone of bone injury, that is, actual and potential destruction of bone, and (*b*) actual mensuration of existing anatomic deformities of bone for purposes of record and subsequent comparison.

2. Treatment should be directed toward the prevention of functional and cosmetic failure through the correction and prevention of anatomic deformity. This is best accomplished in most cases by (*a*) putting the hand in slight flexion, ulnar deviation and supination, with volar and dorsal splints, the latter to extend above the elbow, (*b*) immobilizing the wrist joint for three or four weeks but maintaining active motion of the fingers from the time the splints are applied and (*c*) checking up by roentgenogram two or three weeks after reduction, as lines of comminution stand out most clearly at this time.

SURGICAL AND ANESTHETIC RISK IN CARDIAC DISEASE

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The diversity of opinion in regard to whether or not patients with cardiac disease are good risks for surgical procedures or anesthesia has prompted the present study of the postoperative course in 336 patients with this disease who came to the operating room during a two year period.

In medical textbooks the following statements appear: "Serious uncompensated valvular disease of the heart is a contraindication to general anesthesia." [1] "If loss of compensation is present . . . pulmonary anesthetics should be avoided and local or spinal anesthesia used." [2] "General anesthesia is contraindicated in patients with grave cardiac or kidney disease." [3]

Several authors, including Harvey,[4] who wrote an excellent article on the subject, have studied the cardiac reserve in cases of various types of cardiac lesions and advise as to diagnosis and treatment. No attempt will be made in this paper to elaborate on this phase of cardiac disease.

Necropsy on 77 patients who died consecutively after operation at the Billings Hospital revealed only 1 case of heart failure, 1 case of coronary thrombosis and 4 cases of bronchopneumonia (table 1). This would tend to indicate that the percentage of postoperative deaths due to cardiac disease is relatively low.

The cases of 50 patients with severe cardiovascular disease in which major operations were performed were reviewed (table 2). Although 28 of these patients showed decompensation before operation, there

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From the Department of Surgery, the University of Chicago Clinics.

1. Warbasse, J. P.: Surgical Treatment, Philadelphia, W. B. Saunders Company, 1920, vol. 1, p. 92.

2. Gwathmey, J. T.: Anesthesia, ed. 2, New York, The Macmillan Company, 1929, p. 324.

3. Eliason, E. L.; Ferguson, L. K., and Lewis, E. K.: Surgical Nursing, Philadelphia, J. B. Lippincott Company, 1929, p. 101.

4. Harvey, S. C.: The Complications in Surgery: Their Prevention and Treatment, in Nelson Loose-Leaf Living Surgery, New York, Thomas Nelson & Sons, 1927, vol. 1, chap. 10, p. 571.

were no deaths due to cardiac disease and only 1 patient had mild postoperative decompensation. This patient had a history of angina.

The findings just given stimulated interest in making a detailed study of the immediate and postoperative reactions to anesthesia and operation of 336 consecutive patients with cardiac disease in a series of 6,800 who were operated on (table 3). Approximately two thirds of this group of patients with cardiac disease underwent major operations. It is appreciated that the classification of cardiac disease used is very generalized, and that some of the groups are entirely too small for a statistical study to be very valuable; however, we believe that the data give some indication of the mortality rate in the various diseases.

TABLE 1.—*Deaths Due to Cardiac Disease and Pulmonary Complications in Seventy-Seven Patients at the Billings Hospital Who Died Consecutively After Operation*

Cause of Death	Number of Cases
Heart failure	1 (prostatectomy
Coronary thrombosis	1
Bronchopneumonia	4

TABLE 2.—*Data for Fifty Cases of Severe Cardiovascular Disease in Which Major Operations Were Performed*

Complications	Number of Cases
Decompensation before operation	28
Compensation before operation	22
Intestinal obstruction fourteenth day after operation (mechanical)	1
Severe infection of wound, septicemia, uremia (no albuminuria before operation)	1
Mild decompensation after operation (history of angina)	1

HYPERTENSIVE AND ARTERIOSCLEROTIC HEART DISEASE

There is some diversity of opinion concerning the operative risk in patients with this type of heart disease. Sprague [5] found his greatest mortality in this group. In his series of 75 patients with arteriosclerotic and hypertensive heart disease there were 24 deaths, one half of which were due to cardiac failure. On the other hand, Butler, Feeney and Levine [6] stated that hypertension does not materially increase the operative risk. They found a mortality of 7.3 per cent in 146 patients with a systolic pressure over 160 mm., as opposed to a 5.9 per cent mortality among 245 patients with pressure below 160 mm. They stated

5. Sprague, H. B.: The Heart in Surgery, Surg., Gynec. & Obst. **49**:54 (July) 1929.

6. Butler, S.; Feeney, N., and Levine, S.: The Patient with Heart Disease as a Surgical Risk, J. A. M. A. **95**:85 (July 12) 1930.

that in general patients with very high blood pressures are good surgical risks.

Hypertension.—O'Hare and Hoyt [7] considered the patient with hypertension a fair risk provided there is no associated renal lesion. They stressed the importance of careful following of the blood pressure during operation, the control of bleeding and the early use of fluids and stimulants if indicated.

TABLE 3.—*Data for 336 Consecutive Patients with Heart Disease in a Series of 6,800 Operated On*

Diagnosis	Number of Patients	Poor Recovery	Died	Deaths Due to Cardiac Disease		Deaths Due to Pulmonary Disease		Deaths Due to Combined Cardiac and Pulmonary Disease	Deaths Due to Other Causes	
				Hospital	Home	Hospital	Home		Hospital	Home
Hypertension	91	23	10	2 (spinal anesthesia)	1 (spinal anesthesia)	2 1 due to aspiration)	..	..	3	2
Compensated valvular lesions	60	14	1	..	..	..	..	..	1	..
Compensated myocardial disease	44	11	4	..	..	3	..	1 + renal infection (spinal anesthesia)	..	..
Thyrotoxic heart disease	36	19	3	1	..	..	..	1	1	..
Decompensation (not thyroid)	30	9	5	1 (spinal anesthesia)	1	1 (embolus)	..	1	1	..
Arteriosclerotic heart disease	18	6	3	..	..	..	..	..	3	..
Congenital heart disease	10	1	0	..	..	..	..	..	..	..
Coronary occlusion	8	5	1	1	..	..	..	..	..	..
Heart block	4	0	0	..	..	..	..	..	..	..
Angina pectoris	3	2	1	1	..	..	..	..	..	..
Acute pericarditis	1	1	1	1	..	..	..	..	..	..
Miscellaneous lesions	31	7	2	..	..	..	..	..	2	..
Total	336	98	31	7	2	6	..	3	11	2
Major operations	231									
Minor operations	105									

McQuiston and Allen at the Mayo Clinic [8] studied 350 patients with definite hypertension who underwent major surgical operations. In the majority of these patients myocardial function was normal or nearly so. The operative mortality in this group was 2.6 per cent, which was

7. O'Hare, J. P., and Hoyt, L.: Surgery in Nephritic and Hypertensive Patients, New England J. Med. **200**:1292, 1929.

8. McQuiston, J. S., and Allen, E. V.: The Relationship of Arterial Hypertension to Surgical Risk, in Collected Papers of the Mayo Clinic, Philadelphia, W. B. Saunders Company, 1932, vol. 24, p. 467.

approximately the same as in a group of unselected patients undergoing the same procedures. Death occurring chiefly as the result of hypertension was observed only 3 times, giving an incidence of 0.86 per cent. The authors conclude from this study that patients with hypertension without obvious or with mild myocardial and renal insufficiency tolerate major surgical operations very well.

Since many of the patients in this class are elderly persons, the importance of age in increasing the surgical risk must be considered. Butler, Feeney and Levine stated: "We may conclude that patients with heart disease demonstrate the general rule that increasing age produces an increase in surgical mortality." Lidwill[9] stated that elderly patients who show no definite abnormality on physical examination may be very dangerous subjects for general anesthesia. He finds that they tend to die on the operating table and have little power of recovery.

In this series there were 91 patients with hypertension with a minimum systolic pressure of 170 mm. of mercury, a maximum of 252 mm. and an average of 195 mm. Thirty-seven of these had a systolic blood pressure above 200 mm. There were 47 males and 42 females in the group. Sixty-four of the patients were over 50 years of age, with the incidence in age groups as follows: from 51 to 60, 20 patients; from 61 to 70, 29; from 71 to 80, 13, and from 81 to 90, 2. There were 64 major and 27 minor operations. Among these patients there were 10 deaths, or a mortality of 10.9 per cent. Thirteen patients had poor recovery. There were 3 deaths due to cardiac disease, none of which took place immediately after operation. These 3 patients had received spinal anesthesia. There were 2 deaths from pulmonary complications. One death from bronchopneumonia occurred a few days postoperatively after local plus ethylene-oxygen anesthesia. The other death from pulmonary disease took place seventeen days after operation and was due to aspiration from an ulcerating carcinoma of the esophagus. The patient had had a cannula gastrostomy under local plus ethylene-oxygen anesthesia. The 5 other deaths were from causes unrelated to the cardiac or pulmonary system.

There were 5 patients with cardiac complications with poor recovery (table 4). One of these patients was a woman who had a retrogasserian neurectomy in the sitting position under local plus nitrous oxide-oxygen anesthesia. This patient's condition was poor during operation, with a falling blood pressure and rapid, weak pulse. On the fifth postoperative day she had an anginal seizure, which was her first attack of this nature. A patient with a history suggesting possible coronary involvement had a definite coronary thrombosis after thyroid-

9. Lidwill, M. C.: Cardiac Disease in Relation to Anesthesia, Anesth. & Analg. **9**:145 (July-Aug.) 1930.

ectomy. The other 3 patients had laparotomies under ethylene-oxygen plus ether anesthesia, and all of them showed auricular fibrillation for two to three days after operation.

Five patients had pulmonary complications with recovery. Twenty-four hours after osteoplastic exploration and decompression, pneumonia developed in a patient who had been in very poor condition preoperatively. Bronchopneumonia developed in a man, 85 years of age, seven days after cheiloplasty and excision of the submaxillary glands for carcinoma of the lip, the operation having been performed under local anesthesia. A patient who had an appendectomy under ethylene-oxygen anesthesia had râles and fever on the fourth and fifth days. Atelectasis followed by bronchopneumonia bilaterally occurred in a patient who had a ventral hernia repaired under spinal plus ethylene-

TABLE 4.—*Postoperative Complications with Recovery*

Diagnosis	Number of Cases	Cardiac Complications	Pulmonary Complications	Combined Cardiac and Pulmonary Complications	Other Types
Hypertension	91	4	5	..	4
Compensated valvular lesions	60	3	2	..	8
Compensated myocardial disease	44	3 (spinal anesthesia)	2	..	2
Thyrotoxic heart disease	36	0	2	1	4
Decompensation (not thyroid)	30	2	..	..	2
Arteriosclerotic heart disease	18	..	1	..	2
Congenital heart disease	10	1	..	..	..
Coronary occlusion	8	4	..	..	..
Heart block	4	..	..	..	..
Angina pectoris	3	1	..	..	..
Acute pericarditis	1	..	..	..	..
Miscellaneous lesions	31	..	..	..	..
Total	336	28	12	1	27

oxygen anesthesia. The findings in the chest in a patient who underwent nephrectomy under ethylene-oxygen anesthesia suggested atelectasis or pneumonia.

SUMMARY.—Thus it may be seen that among 91 patients with hypertension there were only 3 deaths due to cardiac disease. Each of these 3 patients was classed as a poor operative risk. Spinal anesthesia was employed. One patient died of cardiac failure several days after operation. Another patient died of cardiac failure several weeks after being discharged. The third death was due to terminal cardiac dilatation after the patient had successfully recovered and been discharged and then readmitted some weeks later. Some authors, perhaps, would class all 3 of these deaths as due to spinal anesthesia.

Arteriosclerosis.—There were 18 patients with arteriosclerosis. The maximum age was 86, the minimum 49 and the average 67. There were 16 males and 2 females in this group. Eleven major and 7 minor operations were performed. There were 3 deaths (16.6 per cent mor-

tality), all of which occurred many days after operation and from causes unrelated to the cardiac or pulmonary system. One patient made a poor recovery when atelectasis developed following ether anesthesia.

SUMMARY.—Although 3 of 18 patients with arteriosclerotic heart disease died, none of the deaths was due to heart disease. In no instance was there an aggravation of the preexisting heart disease.

Type of Anesthesia.—The best type of anesthesia to employ in cases of hypertension or arteriosclerosis has been much discussed. Many persons consider local anesthesia the method of choice, particularly for patients with arteriosclerosis. Horine [10] stated that general anesthesia may be used in many cases if all cyanosis is avoided but that local anesthesia is preferable, especially if there is any evidence of congestive heart failure or anginal pain. He warned against the use of chloroform or spinal anesthesia because of the marked fall in blood pressure accompanying the use of these agents, with frequently resulting cerebral anemia. He stated that local anesthesia is the only method permissible for patients with arteriosclerosis and associated coronary involvement. Horine urged also that no ephedrine or epinephrine be used in the local solution, for two reasons: first, because of the tachycardia which follows the sympathetic stimulation, and, second, because of the possibility of vasoconstriction with an elevation of blood pressure which may produce coronary thrombosis. This is also a factor to be considered in spinal anesthesia, since ephedrine is customarily employed with this type of anesthesia. It is important to avoid excitement during the period of induction, since Hewitt [11] reported cases of cerebral hemorrhage resulting in patients with arteriosclerosis who struggled during anesthesia.

For the patients with arteriosclerosis the types of anesthesia used were: local, in 9 cases; spinal, in 5 cases, and ethylene-oxygen plus ether and nitrous oxide-oxygen in 1 instance each.

For the patients with hypertension the anesthetics were as follows:

Ethylene-oxygen	29
Local	28
Spinal	10
Ethylene-oxygen plus ether	10
Local plus ethylene-oxygen	3
Nitrous oxide-oxygen	3
Spinal anesthesia plus ethylene-oxygen	2
Nitrous oxide-oxygen plus local	2
Ethylene-oxygen and ether (drop)	2
Ether, caudal and sacral	each 1

10. Horine, E. F.: Anesthesia in Heart Disease, Anesth. & Analg. **13**:129 (May-June) 1934.

11. Hewitt, F. W.: Anesthetics, ed. 4, New York, The Macmillan Company, 1912, p. 142.

Ethylene-oxygen and local anesthesia were most frequently employed. Ethylene-oxygen anesthesia was used alone, with local anesthesia or with small amounts of ether. In the patients receiving these types of anesthesia there was only 1 bad result, namely, in the patient in whom coronary thrombosis developed two days postoperatively. The results seem to justify the conclusion that the use of ethylene and oxygen is not contraindicated for these patients.

COMPENSATED VALVULAR LESIONS

The presence of compensated valvular defects seems to add little to the surgical risk, according to George and Louis Herrmann.[12] Butler, Feeney and Levine[6] reported 10 deaths in a series of 120 patients, a mortality of 8.3 per cent.

The results in this series of 60 patients with compensated organic valvular lesions seem to substantiate the belief of previous authors that these patients are good surgical risks.[13] There was 1 death, a mortality rate of 1.6 per cent. This patient died three days after operation for a ruptured appendix and peritonitis. The cause of death was unrelated to the pulmonary or cardiac systems. There were 39 female and 21 male patients in this series. Thirty of the operations were major, and 30 were minor.

The ages varied from 3 to 54 years, the average age being 25. A wide variety of types of anesthesia were used: ethylene-oxygen in 13 operations; local, in 12; nitrous oxide-oxygen, in 11 (8 of these were minor operations); ether, in 10; ethylene-oxygen plus ether, in 8; ethylene-oxygen plus ether (open drop), in 4; spinal, in 1, and nitrous-oxide oxygen and ethylene-oxygen, in 1.

Three patients in this group had cardiac symptoms postoperatively during recovery. One showed fibrillation for a day after receiving ethylene and oxygen plus ether for an abdominal hysterectomy. Another patient (a man of 44) had fibrillation lasting four days after receiving nitrous-oxide and oxygen for an open reduction of a fractured tibia and fibula. One child had symptoms of acute cardiac dilatation for a few days after receiving ether for the open reduction of a hip.

Two patients had pulmonary complications during recovery. One child recovering from scarlet fever had pneumonia two days after receiving nitrous-oxide and oxygen for a myringotomy, and one 36 year old woman with preoperative sibilant râles had a cough for a few days after receiving ethylene and oxygen for repair of an eventration.

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12. Herrmann, G., and Herrmann, L.: Cardiac Disorders in Surgical Patients: Criteria Used in Estimating the Risk Involved, Texas State J. Med. **30**:183 (July) 1934.

13. Blackford, J. M.; Willins, F. A., and Haines, S. B.: Operative Risk in Cardiac Disease, J. A. M. A. **69**:2011 (Dec. 15) 1917.

SUMMARY.—Thus, in a group of 60 patients with compensated valvular lesions there was but 1 death, and this was unrelated to the cardiovascular system. Three patients had postoperative cardiac symptoms, with recovery.

COMPENSATED MYOCARDIAL DISEASE

Patients with compensated myocardial disease are generally believed to tolerate operations rather well. Butler, Feeney and Levine [6] report a 6.6 per cent mortality for this condition. In the present series of 44 cases there were 4 deaths, a mortality of 9 per cent. There were no deaths from cardiac disease. The 4 deaths occurred from three to five weeks postoperatively. Two of the patients had carcinoma and died of terminal bronchopneumonia five weeks after operation. One, a patient with carcinoma of the stomach, died of peritonitis, subdiaphragmatic abscess and multiple pulmonary abscesses after 2 operations under local anesthesia for suture of a duodenal fistula, and 1 died of bilateral pyelonephritis and retroperitoneal abscess three weeks after receiving a spinal anesthetic for a partial nephrectomy and decapsulation nephrotomy.

The average age of the patients was 52 years. Twenty-nine were females, and 15 were males. Thirty-one major and 13 minor operations were performed. A variety of types of anesthesia was employed: ethylene-oxygen, in 12 operations; local, in 11; ether, in 3; spinal, in 3; nitrous oxide-oxygen, in 5 (4 of these were minor operations); ethylene-oxygen plus ether, in 6; ethylene-oxygen plus local, in 3, and ethylene-oxygen plus ether (drop), in 1.

There were 3 cardiac and 2 pulmonary postoperative complications in the group that recovered. A man of 64 had a variable blood pressure and fibrillation for seven days after receiving ethylene and oxygen plus ether for an exploratory laparotomy and removal of material for biopsy from a retroperitoneal tumor. A woman of 30 had cyanosis and fibrillation for several minutes after receiving a spinal anesthetic. A woman of 54 had a rapid weak pulse and dependent edema for several days after receiving a local anesthetic plus ethylene and oxygen for a subtotal gastrectomy.

In regard to the postoperative pulmonary complications, 1 patient had atelectasis two days after receiving ethylene and oxygen plus ether for repair of a ventral hernia, and a patient with alcoholism had a cough for three days after receiving ethylene and oxygen and ether for a cholecystectomy.

SUMMARY.—Of 4 deaths in 44 cases of compensated myocardial disease, none was attributed to the cardiovascular system. Three patients had cardiac symptoms during recovery from major operations, 1 having received a spinal anesthetic.

THYROTOXIC HEART DISEASE

Patients with thyrotoxic heart disease have frequently been thought to be very poor risks. However, in recent years, with improvement in medical and surgical management, the danger has been much reduced. Lahey [14] reported a mortality of 3.6 per cent among 138 patients. Herrmann and Herrmann [12] stated that heart disease of thyrotoxic origin has a less serious surgical significance than either rheumatic or arteriosclerotic heart disease. In Sprague's [5] 14 cases there was only 1 death in the hospital. Ramsey [15] emphasizes the importance of careful supervision of these patients both before and after operation.

There were 36 patients with thyrotoxic heart disease in this series. There were 3 deaths, a mortality of 8.3 per cent. Twenty-seven of the patients were females, and 9 were males, with a range in age of from 14 to 70 years and an average age of 48. Seven of these patients had auricular fibrillation when they came to the operating room but were not bad risks. Of these 7, 3 had received digitalis preoperatively. Five of the patients with thyrotoxic heart disease had marked cardiac failure preoperatively. Four of these received digitalis before operation. The fifth patient did not receive digitalis, and she had an excessively stormy convalescence. All the patients with thyroid disease had received compound solution of iodine U. S. P. before operation.

A woman of 26 who had a thyroidectomy with ethylene-oxygen anesthesia died on the day of operation from tracheal compression due to hemorrhage. A woman of 42 who was operated on under local anesthesia died two days later of an "asthenic reaction to thyroidectomy." The third death followed thyroidectomy in a man of 59, who succumbed to cardiac failure and pneumonia seven days after operation.

Ten patients showed cardiac symptoms after thyroidectomy. One of these was a woman, 62 years old, who had an unusually severe reaction. It was believed that in this instance operation should have been delayed until the patient was digitalized. Five patients had auricular fibrillation for from twenty-four to forty-eight hours after operation under ethylene-oxygen anesthesia. Two men had very severe crises following thyroidectomy with local anesthesia. A patient with previous disease of the coronary arteries had an attack of coronary thrombosis after operation. The 2 pulmonary complications were persistent coughs for several days after operation.

The necessity of caring for a patient with thyrotoxicosis before surgical procedures are instituted is strikingly demonstrated in chart 1,

14. Lahey, F. H.: Hyperthyroidism Associated with Cardiac Disorders, Surg., Gynec. & Obst. **50**:139 (Jan.) 1930.

15. Ramsey, R. A.: The Behaviour of the Heart Under Nitrous Oxid-Oxygen Anesthesia, Anesth. & Analg. **9**:33 (Jan.-Feb.) 1930.

which illustrates a case not in this series. The severe reaction following cholecystectomy and gastro-enterostomy for a badly infected gallbladder and a gastric ulcer in a woman with thyrotoxicosis in all probability would have been obviated had it been possible to have treated the thyroid condition first. Unfortunately, cholecystectomy was not the operation of choice in this case.

Many authors have advised the use of local anesthesia for the patient with thyrotoxicosis with cardiac damage. Horine [10] stated that it is the method of choice unless the patient is unduly apprehensive, in which

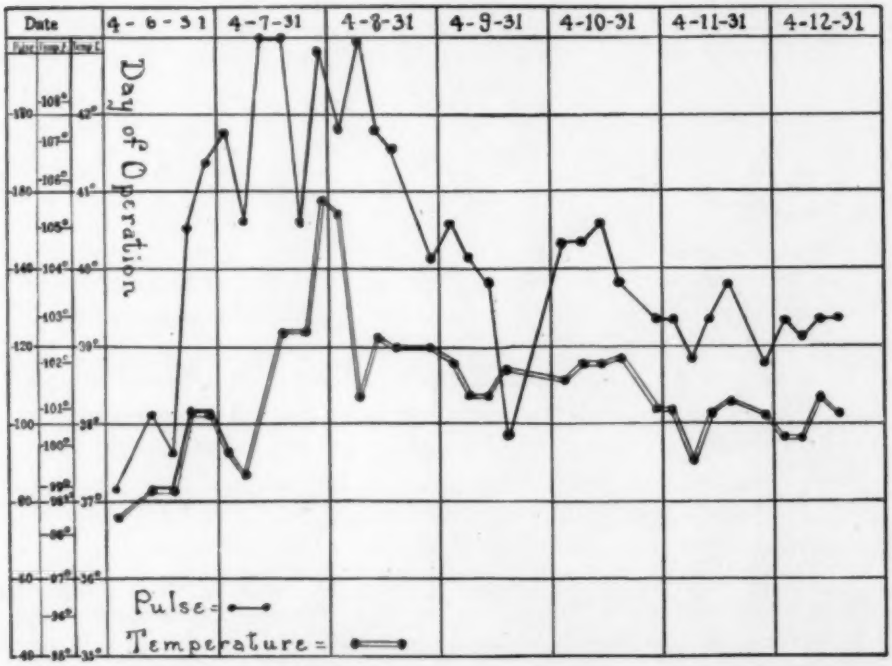

Chart 1.—Record of the postoperative course of a patient with cardiac disease complicated by thyrotoxicosis.

case an inhalation anesthetic must be given. He believes that auricular fibrillation in these patients is not the contraindication to general anesthesia that it is in patients with rheumatic heart disease. Ramsey [15] recommended that nitrous oxide and oxygen be employed but stressed the need for a high concentration of oxygen. He observed marked dilatation of the right heart during operation in patients who had insufficient oxygen with nitrous oxide anesthesia, but by avoiding all cyanosis he can safely administer this agent. Lahey [14] advised the use of ethylene and oxygen in all cases unless the blood pressure is markedly elevated. He found it as safe and more satisfactory to the patient than

local anesthesia. In this series ethylene-oxygen anesthesia has been most frequently used. Twenty-five patients received ethylene-oxygen and 7 local anesthesia, while in 4 cases ethylene-oxygen and local anesthesia were combined. Ethylene-oxygen anesthesia has been found very satisfactory in such cases and appears superior to nitrous oxide-oxygen anesthesia because of the higher percentages of oxygen which may be administered.

SUMMARY.—Thus, 1 death in a series of 36 patients with thyrotoxic heart disease who underwent operation is considered a postoperative death due to cardiac disease. This patient died of so-called "asthenic reaction to thyroidectomy" two days after having had a thyroidectomy under local anesthesia. Since the chart is not complete, this may not have been a death due to cardiac disease. One patient, a man of 59 years, died of cardiac failure and pneumonia seven days after operation under local anesthesia. He was a poor surgical risk, with auricular fibrillation, myocardial insufficiency and generalized arteriosclerosis. Treatment with digitalis was started four days before operation and continued postoperatively. The postoperative course was not alarming until the fifth postoperative day.

Since 9 patients had cardiac and 1 patient had cardiac and pulmonary complications after operation, it is obvious that postoperative cardiac symptoms not infrequently occur in patients with thyrotoxic heart disease.

Proper preoperative medical management of thyrotoxic heart disease is apparently an important factor in decreasing the postoperative morbidity rate.

DECOMPENSATION (NOT DUE TO THYROID DISTURBANCE)

Cardiac decompensation is generally believed to increase the danger of operation. Herrmann and Herrmann[12] stated: "Congestive heart failure . . . must be considered as definitely contraindicating surgical treatment in anything except the most urgent emergencies."

Butler, Feeney and Levine[6] reported a series of 50 operations on 50 patients with congestive heart failure, with a mortality of 17.1 per cent.

In this series there were 30 patients with congestive heart failure preoperatively. Of this number, 4 died, giving a mortality of 13.3 per cent. There were 18 males and 12 females in this group. Twenty-three major and 7 minor operations were performed. The maximum age was 78 years, and the minimum 43, with an average of 62. The types of anesthesia used for the entire group were: ethylene-oxygen, in 13 cases; local, in 12; spinal, in 2; ethylene-oxygen plus ether, in 2, and sacral, in 1.

The 4 deaths were not all of cardiac nature. A man of 68 had fibrillation preoperatively, with râles in the chest and a basal metabolic rate of +28. He received digitalis and compound solution of iodine U. S. P. for three days before the second stage of a prostatectomy under spinal anesthesia, and the administration of digitalis was continued after operation. He died four days later of cardiac failure. An attempted suprapubic prostatectomy in a 78 year old man was followed thirty-seven days later by death from carcinoma of the prostate and obstruction of the urinary tract. A 55 year old man had a partial prostatectomy and insertion of radium with ethylene-oxygen plus ether anesthesia. Four days postoperatively myocardial failure developed, and he died six weeks later with metastases of carcinoma to the pelvis and neck and terminal bronchopneumonia. There had been no preoperative administration of digitalis in this case. The fourth death occurred in a 67 year old man who had a transurethral electro-

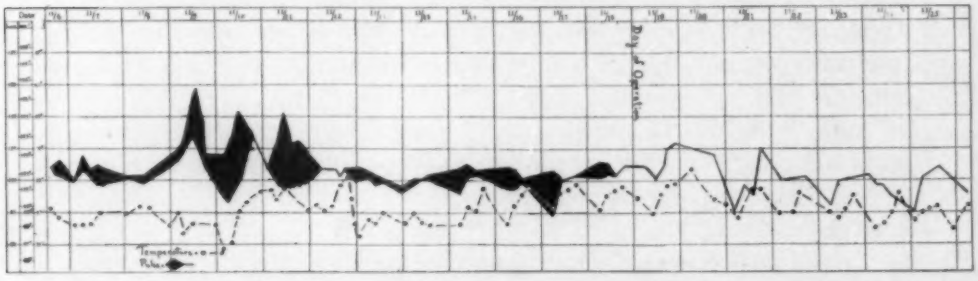

Chart 2.—Record of the preoperative and postoperative course of a patient with severe decompensation.

resection of the prostate under spinal anesthesia. This patient did not receive any cardiac therapy either preoperatively or postoperatively. He was apparently making a good recovery and had been allowed to be up in a chair for several days before death occurred suddenly from a pulmonary embolus.

Chart 2 illustrates the course following amputation of the midportion of the thigh of a middle-aged woman with severe decompensation. This patient entered the hospital with severe decompensation of some duration. She was given digitalis, and on the thirteenth day of hospitalization fibrillation ceased. The following day operation was performed under ethylene-oxygen anesthesia. The recovery was uneventful.

Chart 3 illustrates a case not in this series but is presented because it represents an extreme degree of preoperative decompensation. This illustration was lent by Dr. Edmund Andrews. Mrs. C. B. was a middle-aged woman who for twenty years had been bedridden with far advanced myocardial failure, and her demise had been expected at

any time during this period. She suffered from a ruptured appendix. Figure 7 shows the uneventful course following an appendectomy under local anesthesia.

SUMMARY.—In 30 patients with preoperative decompensation there were 5 deaths, 1 of which was entirely due to cardiac disease and in 2 cardiac disease played an important rôle. Four days after operation cardiac failure caused the death of a patient who had received a spinal anesthetic. Two patients died several weeks postoperatively of combined

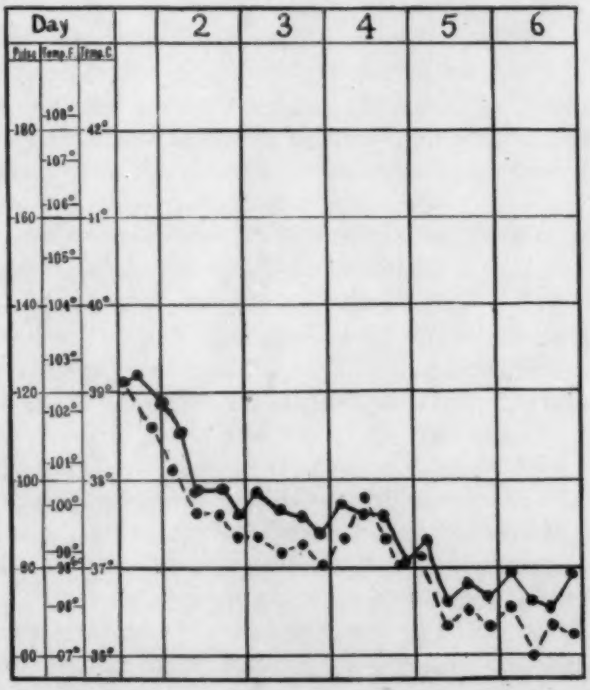

Chart 3.—Record of the postoperative course of a patient with extreme decompensation. The solid line indicates the temperature; the broken line, the pulse rate.

cardiac failure and extensive metastasis of carcinoma, 1 having pneumonia also. A major operation under spinal anesthesia was followed by death from pulmonary embolism during an apparently uneventful recovery.

CONGENITAL HEART DISEASE

Death or signs of collapse, particularly with ethyl chloride, chloroform or ether anesthesia, are not infrequently reported in cases with associated congenital heart disease.[11] Lidwill[9] stated that congenital heart disease offers practically no contraindication in the majority of cases. However, he reported a death from cardiac disease following

ethyl chloride and ether anesthesia. Harvey [4] stated that the patient with congenital cardiac disease is ill suited in infancy for the imposition of sudden additional strain, and any operative procedures must therefore be carefully adjusted to the seriousness of the lesion and the degree to which it is compensated.

This series of patients with congenital heart lesion includes 10. There were no deaths. One patient had tachycardia for several days after receiving ether anesthesia for a tonsillectomy and adenoidectomy. Of the 10 patients, 6 were females and 4 males. There were 9 minor operations with ether anesthesia and 1 major operation with ethylene-oxygen plus ether anesthesia. The patients ranged in age from 20 months to 13 years, the average age being 5½ years.

SUMMARY.—With no deaths and but 1 instance of a cardiac complication during recovery in a series of 10 patients with congenital heart disease, it appears that surgical intervention is not to be feared for this group.

CORONARY OCCLUSION AND ANGINA PECTORIS

Coronary occlusion markedly increases the surgical risk. Butler, Feeney and Levine [6] found their greatest mortality (44.5 per cent) in patients with this condition. However, among persons for whom the correct diagnosis had been made and proper treatment instituted, their mortality was only 14.3 per cent. Patients for whom the diagnosis had not been made had a mortality of 75 per cent. Proper preoperative diagnosis is of great importance both from the standpoint of adequate treatment and to avoid surgical procedures during attacks of coronary thrombosis. Herrmann and Herrmann [12] stated that patients with coronary occlusion may be subjected to surgical treatment if they are carefully prepared but that the risk is always great.

Among this series of patients there were 8 with coronary occlusion. Two of these had more than 1 operation, there being 10 major and 3 minor procedures. The average age was 49 years, with a maximum of 67 and a minimum of 40. There were 3 females and 5 males. One death occurred, giving a mortality of 12.5 per cent. The types of anesthesia used were: ethylene-oxygen, in 6 cases; local, in 5, and spinal and ethylene-oxygen plus ether, in 1 each. Phelps [16] advised against the prolonged administration of nitrous oxide and oxygen in these cases.

The death occurred after 5 operations on a man of 45, who had coronary occlusion and multiple emboli. Two of the operations performed were embolectomies, and 3 were amputations. Local, ethylene-oxygen and ethylene-oxygen plus ether were types of anesthesia used.

16. Phelps, A. E.: Coronary Disease in Surgical Patients, Ann. Surg. **87**:32 (Jan.) 1928.

In addition to this case, there were 4 others with poor postoperative recovery. All the complications were cardiac. One patient had transient tachycardia, and 2 had attacks of coronary thrombosis. These 3 patients had received ethylene-oxygen anesthesia. In the fourth patient, who had auricular fibrillation preoperatively myocardial failure developed after a suprapubic cystotomy under local anesthesia.

SUMMARY.—Since 1 of 8 patients with coronary occlusion died of cardiac disease, the mortality rate of 12.5 per cent apparently indicates that anesthesia and surgical operations have a graver risk in this type of cardiac disease than in the types previously mentioned.

Patients with angina pectoris are also poor risks. Butler, Feeney and Levine reported a mortality of 7.7 per cent in 41 operations on 35 patients. They found danger of coronary thrombosis in these patients. Sprague [5] reported 4 deaths in a series of 13 cases. There were only 3 patients suffering from angina pectoris in the present series, and of these 1 died (a mortality of 33.3 per cent), while 1 had a poor recovery. A man of 62 with a blood pressure of 220 systolic and 110 diastolic and frequent anginal attacks had a suprapubic prostatectomy under ethylene-oxygen anesthesia. For ten days he had a low grade fever. On the eleventh day he had a fainting attack accompanied by precordial pain. He recovered and was discharged from the hospital, but his activity was greatly restricted.

The death in this group was that of a patient who had a rectal polyp excised under local anesthesia. Two and one-half hours after the operation he died suddenly from what appeared clinically to be coronary thrombosis. Unfortunately, autopsy was not permitted in this case.

SUMMARY.—One postoperative death from cardiac disease in 3 cases of angina pectoris indicates a grave risk when one contemplates anesthesia or surgical intervention in the presence of this type of cardiac disease.

HEART BLOCK

Herrmann and Herrmann [12] stated that heart block and bundle branch block are very severe conditions which predispose to ventricular cessation during surgical procedures. They urged that only the most necessary operations be attempted on these patients. Lidwill [9] expressed the belief that patients with heart block may withstand operation well, provided there is no decompensation and no Adams-Stokes syndrome. Blackford [13] and his collaborators reported on 7 patients with partial or complete heart block who were operated on with no deaths.

In this series there were only 4 cases of heart block. Three of the patients were men and 1 was a woman. The maximum age was 78 and the minimum 25. There were 3 major operations and 1 minor operation.

Local anesthesia was employed in 3 of these cases, while in 1, in which a radical mastoidectomy was performed, ethylene-oxygen plus ether anesthesia was used. All the patients survived the operation, and all had uneventful recoveries. One man, 78 years old, who had a partial orchidectomy with local anesthesia had had a suprapubic prostatectomy with ethylene-oxygen anesthesia four years previously. At the time of the first operation heart block was present.

SUMMARY.—The 4 cases of heart block with no deaths or postoperative complications suggest that this type of cardiac disease does not contraindicate anesthesia or operation.

ACUTE PERICARDITIS

Among the patients in this series there was only 1 with acute pericarditis. This was a child of 3 years who entered the hospital acutely ill. She had decompensation for two weeks before admission and had been in an oxygen tent almost constantly. Five operations were performed: incision and drainage for acute osteomyelitis of the shoulders and thighs, a myringotomy, 2 incisions and drainage of mediastinal abscesses and a pericardotomy. She died of pyopericardium and septicemia. Ether and local anesthetics were employed during the various operations.

MISCELLANEOUS CARDIAC LESIONS

Miscellaneous cardiac lesions include questionable rheumatic heart disease, cardiac murmurs, bradycardia and all lesions not clearly diagnosed. There were 31 patients with such lesions in this series, with 2 deaths, or a mortality of 6.4 per cent. There were 12 males and 19 females, with an average age of 35, a maximum of 71 and a minimum of 4 years. Seventeen major and 14 minor operations were performed. The types of anesthesia used were: ethylene-oxygen, in 6 cases; local, in 10; ether, in 7; ethylene-oxygen plus ether, in 4; nitrous oxide-oxygen, in 3 (minor operations), and spinal, in 1.

The 2 deaths were unrelated to the cardiac or pulmonary systems. One occurred seven days postoperatively (local anesthesia) from respiratory failure in a patient with a pineal tumor. The other death was caused by streptococcic septicemia and followed a radical mastectomy under ethylene-oxygen anesthesia. There were 5 other postoperative complications, none of them cardiac or respiratory. Two of the complications with recovery were hemorrhage after tonsillectomy.

COMMENT

In the 170 cases reported by Sprague,[5] 5 of the patients died on the operating table. There were no deaths on the operating table in the present cases.

There were 4 deaths during the first four postoperative days. One male died suddenly of apparent coronary thrombosis two and one-half hours after the removal of a rectal polyp under local anesthesia. One patient died of hemorrhage on the day of operation following a thyroidectomy. Another patient died on the second day after thyroidectomy of an "asthenic reaction to thyroidectomy." One patient died on the fourth postoperative day of cardiac failure. All the other deaths occurred later, some as late as from five to six weeks after operation.

Following 336 operations, considering the patients with each type of cardiac disease separately, the mortality rates were as follows: for patients with angina pectoris, 33.3 per cent; for patients with arteriosclerotic heart disease, 16.6 per cent; for patients with decompensation, 13.3 per cent; for patients with coronary occlusion, 12.5 per cent, and for patients with hypertensive heart disease, 10.9 per cent. The patients with other types of cardiac disease had a lower death rate (table 5).

TABLE 5.—*Mortality Rate Following Three Hundred and Thirty-Six Operations*

Preoperative Diagnosis	Total Death Rate, Percentage	Death Rate for Cardiac Disease, Percentage
Angina pectoris	33.3	33.3
Arteriosclerotic heart disease	16.6	0
Decompensation	13.3	3.3
Coronary occlusion	12.5	12.5
Hypertensive heart disease	10.9	3.2
Compensated myocarditis	9.0	0
Thyrotoxic heart disease	8.3	2.7
Miscellaneous heart disease	6.4	0
Compensated valvular heart disease	1.6	0
Heart block	0	0
Congenital heart disease	0	0

In considering the patients who died postoperatively of cardiac disease, it is seen that 33 per cent died of angina pectoris, 12 per cent of coronary occlusion, 3.3 per cent of decompensation, 3.2 per cent of hypertensive heart disease and 2.7 per cent of thyrotoxic heart disease.

In this series there were 27 patients who recovered but who suffered from postoperative cardiac complications (table 4). These complications were as follows: fibrillation, 12 cases; fibrillation and associated thyroid crises, in 8; coronary thrombosis on the second postoperative day, in 2; anginal attack on the fifth postoperative day, in 1; anginal attack on the eleventh postoperative day, in 1; symptoms of myocardial insufficiency, in 1, and tachycardia for several days after operation, in 1.

It is of interest to note that in 1 patient who had had an uneventful recovery following a previous operation under local anesthesia not included in this series, fibrillation developed following ethylene-oxygen anesthesia with moderate lack of oxygen and straining respiration. Two patients had an uneventful course after ethylene-oxygen anes-

thesia for major operations; in each instance when ether was added to the ethylene and oxygen as a second anesthetic, fibrillation occurred.

Two postoperative cardiac complications followed nitrous oxide-oxygen anesthesia. An elderly woman had an anginal attack following a retrogasserian neurectomy performed with the patient in the sitting position, and a man of 34 years had fibrillation for four days following a bone graft to the lower extremity.

It has been found by clinical observation [15] that the diseased heart cannot tolerate lack of oxygen or asphyxia. Since lack of oxygen is frequently associated with nitrous oxide-oxygen anesthesia,[17] the results just mentioned are not surprising. Nitrous oxide also causes a marked rise in the blood pressure.[18] The importance of avoiding asphyxial strain is also stressed by Hewitt.[11]

The 12 postoperative pulmonary complications with recovery were as follows: pneumonia, in 4 cases; cough, in 4; atelectasis, in 2, and râles of a few days' duration, in 2. With ethylene-oxygen plus ether anesthesia (with a large amount of ether employed) 28.5 per cent of the operations were followed by pulmonary complications. In the cases in which ether anesthesia was used 6.2 per cent of the patients had pulmonary complications, and in the cases in which nitrous oxide-oxygen anesthesia was used 4.3 per cent had pulmonary complications. The use of local or ethylene-oxygen anesthesia resulted in the lowest number of pulmonary complications.

Table 6 shows the relationship of anesthesia to the final cardiac condition.

Three patients among the 23 receiving spinal anesthesia had cardiac complications related to the anesthesia (13 per cent). In the cases in which ethylene-oxygen plus ether anesthesia was used 5.7 per cent of the operations were followed by death due to cardiac disease. Fewer complications occurred postoperatively after the use of local anesthesia, and fewer deaths due to cardiac disease resulted with the use of local or ethylene-oxygen anesthesia.

SUMMARY.—It must be emphasized that a high percentage of the operations performed on patients with grave cardiac lesions were operations of necessity, not of selection. A high percentage of the operations were major surgical procedures, many of them very extensive. In view of these facts, it is of interest to note the low percentage of actual deaths from cardiac disease that occurred.

There were only 27 instances (8 per cent) of postoperative cardiac complications with recovery in a series of 336 cases of surgical pro-

17. Cushny, A. R.: Textbook of Pharmacology and Therapeutics, ed. 7, Philadelphia, Lea & Febiger, 1918, p. 228.

18. Gwathmey,[2] p. 30.

cedures on persons with cardiac disease. This suggests that the complications which can be expected are not of sufficiently frequent incidence to warrant the rejection of anesthesia and surgical intervention for patients to whom operation offers improvement in their condition.

Since only 6 deaths due to pulmonary disease and 3 due to cardiac-pulmonary disease occurred in 336 cases, the incidence of death due to pulmonary disease in persons with heart disease is low. Few of the pulmonary complications or deaths were directly related to the cardiac disease.

TABLE 6.—*Relationship of Anesthesia to the Final Cardiac Condition*

Anesthesia	Number of Cases	Deaths Due to Cardiac Disease: Hospital: Related	Deaths Due to Cardiac Disease: Hospital: Unrelated	Deaths Due to Cardiac Disease: Home	Deaths Due to Pulmonary Disease: Hospital: Related	Deaths Due to Pulmonary Disease: Hospital: Unrelated	Deaths Due to Pulmonary Disease: Home	Deaths Due to Other Causes: Hospital	Deaths Due to Other Causes: Home	Cardiac Complications with Recovery: Related	Cardiac Complications with Recovery: Unrelated	Pulmonary Complications with Recovery: Related	Pulmonary Complications with Recovery: Unrelated
Ethylene-oxygen	106	..	1*	..	..	..	..	4	..	11	3†	3	..
Local	101	1‡	1§	..	1‡	3	..	4	1	3	1	1	1
Ethylene-oxygen + ether	35	2#	..	..	..	..	..	..	..	3	..	1	..
Ether	32	..	1¶	..	..	..	..	1	1	2	1	2	..
Spinal	23	3	..	1	..	1‖	..	..	..	1	..	..	..
Nitrous oxide-oxygen	23**	..	..	..	..	..	..	..	..	1	..	1	..
Local + ethylene-oxygen	10	..	..	1	..	..	..	..	..	1	..	..	..
Ethylene-oxygen + ether	7	..	..	..	..	..	..	..	..	..	..	2	..
Local + nitrous oxide-oxygen	2	..	..	..	1	..	..	..	..	1	..	..	..
Sacral	2	..	..	..	..	..	..	2	..	..	..	..	..
Spinal + ethylene-oxygen	2	..	..	..	..	..	..	..	..	..	..	1	..
Caudal	1	..	..	..	..	..	..	..	..	..	..	..	..
Nitrous oxide-oxygen and ethylene-oxygen	1	..	..	..	..	..	..	..	..	..	..	..	..
Total	345	6	3	2	2	4	..	11	2	23	5	11	1

* Coronary occlusion.
† Angina pectoris and coronary thrombosis.
‡ Thyrotoxic heart disease.
§ Angina pectoris.
# Later.
¶ Pericarditis.
‖ Embolus.
** Thirteen minors.

SUMMARY

From the results of this survey the following assumptions may be made:

Since there were only 6 deaths due to cardiac disease and 2 deaths due to pulmonary disease related to the surgical intervention and anesthesia in 336 patients who underwent 345 operations, the resulting mortality of 2 per cent indicates that as a group patients with cardiac disease are fairly good surgical risks.

Angina pectoris, coronary occlusion, decompensation, hypertension and thyrotoxic heart disease are, in the order named, the most serious diseases with which one has to deal.

Contrary to the belief of several authors, inhalation anesthesia, particularly ethylene-oxygen anesthesia, is safe when a high percentage of oxygen is used and asphyxia or struggling is avoided. Ethylene-oxygen and local anesthesia have given the most satisfactory results in this series of cases. The use of spinal, ether or nitrous oxide-oxygen anesthesia has increased the incidence of postoperative complications and death.

Dr. Edmund Andrews assisted in making this study, and Dr. Cornelius Hospers, Dr. Francis Murphy and Dr. William Johnson assisted in reviewing case histories.

SURGICAL TREATMENT OF CARCINOMA OF THE HEAD OF THE PANCREAS AND OF THE AMPULLA OF VATER

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The ultimate results of radical operation on the pancreas and ampulla of Vater have not been as successful as one would desire because of several factors, the chief of which are: (1) the insidious onset of disease; (2) the poor condition of the patients; (3) the relative inaccessibility of the lesions; (4) the proximity of important structures which cannot be sacrificed, and (5) technical difficulties. Thus there has been a great tendency to treat such lesions in a more conservative manner. This being the case, it seemed of interest to compare the results obtained from the radical procedures with those following purely palliative operations in order to ascertain whether one is justified in attempting complete removal of the diseased tissue.

This study is based on 179 cases, in 158 of which the lesion originated in the head of the pancreas; in the remaining 21 it originated in the ampulla of Vater. The average age of these patients, 70.4 per cent of whom were men, was 56.3 years. The youngest patient was a man of 23 and the oldest a man of 77. Preliminary cholecystostomy was performed in 10 per cent of the cases in order to promote biliary drainage and to improve the general condition of the patient before attempting a more radical procedure.

Radical resections of the ampulla of Vater have not been numerous. Halsted [1] is credited with having performed the first operation of this nature in February 1898, and his patient lived for nine months. Mayo [2] performed the second resection of the ampulla in January 1901. The cases reported in the literature up to 1927 were carefully reviewed by Cohen and Colp.[3] They found that 59 radical operations had been

1. Halsted, W. S.: Contributions to the Surgery of the Bile Passages, Especially the Common Bile-Duct, Bull. Johns Hopkins Hosp. **11**:1 (Jan.) 1900.

2. Mayo, W. J.: Cancer of the Common Bile-Duct: Report of a Case of Carcinoma of the Duodenal End of the Common Duct, with Successful Excision, in Collected Papers of the Mayo Clinic, Philadelphia, W. B. Saunders, 1909, vol. 1, p. 365.

3. Cohen, Ira, and Colp, Ralph: Cancer of the Periampullary Region of the Duodenum, Surg., Gynec. & Obst. **45**:332 (Sept.) 1927.

performed for carcinoma of the periampullar region, transduodenal resection being performed in 53 cases with a mortality of 44 per cent. Since 1927 other surveys have been made by Walters,[4] Potter,[5] Lauwers [6] and Hunt,[7] the last-mentioned finding 17 cases in addition to presenting 1 of his own.

Twenty-one patients with carcinoma of the ampulla of Vater have been submitted to operation at the Mayo Clinic. In 14 cases a purely palliative procedure seemed indicated. Thus, cholecystogastrostomy was performed twelve times and cholecystoduodenostomy and choledochoduodenostomy once each. Four of the patients did not recover from the operation, but the average postoperative life of those who did was thirteen and nine-tenths months. In the 7 remaining cases in this group the lesion appeared to be amenable to complete extirpation. Consequently, resection of the ampulla of Vater together with the tumor was carried out (table 1).

Four of the 5 patients who survived the operation were completely relieved of their symptoms and lived for one year and three months, two

TABLE 1.—*Radical Operations for Carcinoma of the Ampulla of Vater*

Operation	Cases
Resection, transduodenal	2
Resection, transduodenal, and choledochotomy	2
Resection, transduodenal, and choledochoduodenostomy	1
Resection, transduodenal, choledochoduodenostomy and cholecystostomy	1
Resection, transduodenal, and cholecystoduodenostomy	1
Total	7

years and two months, two years and two months and three years, respectively. One patient was not traced. When an attempt was made to compare these results with those obtained following palliative operations, it was found that the average postoperative life of the patients in the former group was one year longer. On the other hand, however, palliative procedures did not entail as great an operative risk, and in addition 1 of the patients lived two years, free from symptoms until just before the end. Since it was difficult to arrive at definite conclusions while one was dealing with groups composed of so few cases, it was deemed advantageous for the sake of comparison to select a large series of cases of conditions closely related to malignant lesions of the ampulla

4. Walters, Waltman: Resection of the Common and Hepatic Bile Ducts and Ampulla of Vater for Obstructive Lesions, Surg., Gynec. & Obst. **56**:235 (Feb.) 1933.

5. Potter, E. B.: Successful Resection of Common Biliary Duct for Carcinoma of Ampulla of Vater, Ann. Surg. **98**:369 (Sept.) 1933.

6. Lauwers, E.: Traitement chirurgical du cancer vatérien, J. de chir. **42**:833 (Dec.) 1933.

7. Hunt, Vern: Personal communication to the authors.

of Vater. Therefore carcinoma of the head of the pancreas, which seemed to fulfil the necessary qualifications, was utilized for this purpose and was made the object of a second study.

Complete removal of neoplasms of the pancreas has been attended with very little success. Few indeed are the cases in which a prolonged survival has been obtained, in spite of the encouraging report of Gordon-Taylor,[8] whose patient has now lived seven years after such an operation. Thus, carcinoma of the head of the pancreas is usually treated by palliative measures similar to those employed for lesions of the ampulla of Vater. Studies of these conservative procedures have been reported by Gorman,[9] Clute,[10] Walters and McVicar,[11] Judd and Parker [12] and Coller and Winfield.[13]

Some form of anastomosis between the biliary tract and the intestines was performed in 158 cases of lesions involving the head of the pancreas. Because of the difficulty encountered in making a definite diagnosis of carcinoma in some instances, this series was divided into two groups and each was studied separately. The first group is composed of 94 cases in which the diagnosis of malignant growth was verified at the time of operation, at subsequent postmortem examination or later by the referring physician. In 64 cases the differentiation of carcinoma and chronic pancreatitis could not be made with certainty, although in the opinion of the surgeon a malignant condition was the more likely in the majority of cases (table 2).

Since the immediate factor which endangers the life of these patients is obstruction of the biliary tract some form of anastomosis between the biliary tract and the intestines is the operation of choice, for it provides prolonged drainage of the biliary system without the loss of bile. The two methods most frequently employed are cholecystogastrostomy and cholecystoduodenostomy. The choice of one or the other of the two procedures was determined solely by the ease with which the stomach or the duodenum could be approximated to the gallbladder. Other portions of the intestines were utilized for the anastomosis only

8. Gordon-Taylor, G.: The Radical Surgery of Cancer of the Pancreas, Ann. Surg. **100**:206 (July) 1934.

9. Gorman, J. J.: Adenocarcinoma of Head of Pancreas, Southwestern Med. **16**:259 (June) 1932.

10. Clute, H. M.: Choledochoduodenostomy in Cancer of Pancreas, S. Clin. North America **13**:617 (June) 1933.

11. Walters, Waltman, and McVicar, C. S.: Relief of Obstructive Jaundice from Tumors in the Head of the Pancreas, Ann. Surg. **89**:237 (Feb.) 1929.

12. Judd, E. S., and Parker, B. R.: Biliary Intestinal Anastomosis for Obstructive Jaundice: Analysis of One Hundred and Thirty-Seven Consecutive Cases, Arch. Surg. **17**:1 (July) 1928.

13. Coller, F. A., and Winfield, J. M., Jr.: Evaluation of Palliative Operation for Cancer of the Pancreas, Am. J. Surg. **25**:64 (July) 1934.

when the stomach and duodenum were not readily available. In one case previous cholecystectomy necessitated some other form of union, and thus choledochoduodenostomy was performed.

Patients suffering from obstructive jaundice always present a poor surgical risk, and this is especially true, in spite of the best of preoperative care, when the lesion involves the head of the pancreas. The three main complications to be feared in this type of case are hemorrhage, hepatic insufficiency and renal insufficiency. The best method of protecting the patient against hemorrhage during and after operation is to give one or more transfusions of whole blood before and after operation. Calcium chloride also has been used intravenously to increase the coagulability of the blood, but just what part it plays is not clearly understood. Since an injured liver can utilize carbohydrates more readily than other nutrient substances, large quantities of 10 per cent solution of dextrose are administered intravenously, either alone or combined

TABLE 2.—*Palliative Operations for Carcinoma of the Head of the Pancreas*

Type of Operation	Diagnosis Verified	Diagnosis Questionable	Total
Cholecystogastrostomy	66	56	122
Cholecystoduodenostomy	15	6	21
Cholecystojejunostomy	7	2	9
Cholecystocolostomy	4	0	4
Choledochoduodenostomy	1	0	1
Reconstructive cholecystogastrostomy*	1	0	1
Total	94	64	158

* Cholecystogastrostomy performed elsewhere previously.

with 1 per cent solution of sodium chloride or 2 per cent solution of racemic sodium lactate. The rôle of racemic sodium lactate is not definitely known, but it seems to aid in restoring hepatic function in some instances. These measures are further supplemented by prescribing a diet high in carbohydrates. The increased intake of fluid just described serves a double purpose in the presence of jaundice, for it is an excellent treatment for a coexisting toxic nephrosis.

The mortality at the hospital for this series of palliative operations was high. The patients who survived the operation, however, were relieved of their most troublesome symptoms, pain, jaundice, pruritus and episodes of chills and fever, except in a very few instances. The patients who derived no benefit from the operation comprised but 4 per per cent of those who survived. These patients were the ones in whom the carcinoma was farthest advanced at the time of operation, and most of them died within three months after the procedure. Obstruction of the pancreatic duct is often one of the terminal complications in these cases.

The average length of life after leaving the hospital for the patients with verified carcinoma of the head of the pancreas was ten and two-tenths months. The patients in whom carcinoma of the head of the pancreas and chronic pancreatitis could not definitely be distinguished lived, on an average, eleven and nine-tenths months. It would appear that the discrepancy between these figures could be accounted for by the inclusion in the latter group of several patients with simple pancreatitis. Furthermore, the fact that some patients with a questionable diagnosis did survive from three to six and a half years lends considerable weight to this opinion. Nevertheless, the number of incorrect diagnoses in a large series of cases is relatively few, for the surgeon can form a rather accurate opinion of the condition with which he is dealing but is restrained from offering a dogmatic statement because a specimen for biopsy was not taken.

COMMENT

Although the results following operation for carcinoma of the ampulla of Vater or for carcinoma of the head of the pancreas leave much to be desired, there is still something to be said in favor of such operations. In spite of the improvement in the methods of diagnosing disease of the biliary tract, in an occasional case there are typical features of carcinoma of the lower end of the common duct in which obstructive jaundice is found to be the result of a calculus. In other cases in which pathologic changes are found in the head of the pancreas it may be difficult to determine the true nature of the condition. If the lesion subsequently proves to be chronic pancreatitis, anastomosis between the biliary tract and the intestines not only provides the best form of treatment, namely, biliary drainage, but is compatible with life when the patient recovers from the disease. These two factors alone justify operation in such cases.

From the foregoing discussion it appears that palliative operations are justifiable; the data presented in this paper also show, however, that the patients with carcinoma of the ampulla of Vater who survive operation live longer following removal of the growth than those who submit to purely palliative treatment for either carcinoma of the ampulla of Vater or carcinoma of the head of the pancreas. It is known that there will eventually be a fatal result in all cases in which an attempt is not made to resect the neoplasm. Thus, although the surgical risk is greater, radical measures offer the only prospect of cure. Even when the outcome is not all what had been anticipated and the growth recurs, the person still may enjoy a longer period of useful life. There are not many surgical procedures now employed successfully that have not undergone the same metamorphosis. Every attempt adds much to the knowledge concerning the disease, and some day a complete cure will

be accomplished. Of course, this is an extremely small series from which to draw definite conclusions, but from the information available at present, radical operations appear to be justified in certain selected cases of carcinoma of the ampulla of Vater in which there is a reasonable chance of procuring a successful result.

SUMMARY

A study was made of 179 patients submitted to surgical intervention for lesions originating either in the head of the pancreas or in the ampulla of Vater. The former was found to be the primary site 158 times; the latter, 21 times.

Carcinoma of the head of the pancreas may be difficult to distinguish from chronic pancreatitis. In cases in which the diagnosis of malignant growth was verified following palliative operations, the patients enjoyed an average of ten and two-tenths months of useful life after leaving the hospital. In the questionable cases in which the same procedures were performed, the patients enjoyed an average life of eleven and nine-tenths months. Only 4 per cent of those who survived obtained no benefit from the operation.

Five of the 7 patients who were subjected to transduodenal resection of the ampulla of Vater for carcinoma recovered, and their average postoperative length of life was twenty-five and eight-tenths months. The patients in this group who survived some form of anastomosis between the biliary tract and the intestines lived, on an average, thirteen and nine-tenths months.

Radical resection of carcinoma of the ampulla of Vater sustains life for a longer period than more conservative treatment, and it offers the only prospect there is of cure.

URINARY CALCULI IN BONE DISEASES

REVIEW OF THE LITERATURE AND REPORT OF CASES

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A review of the literature reveals only an occasional reference to a report of the occurrence of urinary calculi in association with various bone diseases. However, within recent years an increased interest has been manifested in the relation of urinary lithiasis to bone diseases. The World War offered an opportunity to study the effect of suppurative bone lesions (Paul, W. Weber, E. Joseph) and gunshot wounds of the vertebral column (Benda) on calculus formation in the kidneys. W. Weber has recently reported 9 cases and Barr and Charles 7 cases of urinary calculi in association with various bone diseases, i. e., osteomyelitis, vertebral fractures, arthritis, coxitis, tuberculosis of the spine, rickets, fractures, etc.

With the exception of the article by Barr and Charles, the American contributions to the subject of urinary calculi in cases of bone diseases are limited to reports of single cases by various writers, including O'Conor, Harper, Herman, Borman and others, and to general statements on the subject by Eisenstaedt, Squier and Keyser. In a discussion of the etiologic factors concerned in the production of urinary calculi, Eisenstaedt emphasized the rôle of prolonged immobilization for fractures and wounds, especially chronic suppurating lesions involving the bones, and subsequent infection of the urinary tract with Bacillus coli or staphylococci. He also noted the occurrence of urinary calculi following fractures of the spine and stated that the spinal diseases commonly associated with urinary calculi are spondylitis, arthritis deformans and spondylitis deformans. In a comprehensive discussion of the etiologic factors in nephrolithiasis, Squier stressed the rôle of calcium metabolism in the genesis of nephrolithiasis and emphasized the importance of considering the relation of disturbances of calcium metabolism to stone formation in various bone diseases, i. e., osteoporosis, osteomalacia, osteitis deformans, osteopsathyrosis, chronic septic coxitis and severe rickets. He also mentioned the occurrence of renal calculi following traumatic injuries and diseases of the spinal cord and

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compound fractures of long bones in which the healing process has been prolonged.

While it has long been known to the pathologist that calcareous deposits are found in the kidneys and other organs in severe rickets, osteo-arthropathies, bone injuries and tumor metastases, no particular mention is made of the occurrence of renal calculi in these conditions. These so-called calcium deposits or metastases are found in various organs of the body, the kidney being usually the first to be involved and then, in the order of relative frequency, the heart, lungs, stomach and skeletal musculature.

The decided paucity of reports of the association of urinary lithiasis with various bone diseases may be attributed to the fact that frequently it is impossible to establish an etiologic relationship between the urinary calculi and the bone disease inasmuch as the symptoms produced by such calcareous concrements usually occur long after the arrest of the original bone lesion, or the calculi are symptomless and the diagnosis is made only at autopsy. Often their occurrence may be overlooked or not recognized, as attention is directed wholly to the major bone lesion.

It is our purpose in this paper to review the contributions to the subject of urinary lithiasis in bone diseases and to present 14 cases. Four cases occurred following amputation of extremities, 2 following osteomyelitis, 4 following a fracture of the femur or of the pelvis, 1 following tuberculosis of the hips, 1 following arthritis deformans with an associated osteitis deformans and 2 in association with scoliosis. We have also observed 6 cases of urinary lithiasis associated with osteitis deformans, which have been reported elsewhere.

BONE SUPPURATION

Although the relation of focal and systemic infections to the formation of renal calculi has been the subject of much investigation in recent years, little consideration has been given to bone suppuration as a possible etiologic factor. The earliest recorded case of urinary calculus associated with suppurative bone disease was that reported by Adams in 1850: A boy was treated for an infection of the knee joint at the age of 12, and several months later osteomyelitis of the os pubis developed.

The recent reports of Paul, W. Weber, Lepoutre and others in this connection are of extreme importance and have served to establish a definite etiologic relationship between bone suppuration and nephrolithiasis. Paul reported 20 cases of nephrolithiasis in wounded war veterans. There was a definite history of bone suppuration with the associated systemic infection that accompanies osteomyelitis in every case with the exception of one in which a soldier had sustained multiple

shrapnel wounds of the right thigh and buttock. In the discussion of Paul's paper, Herman reported a case of renal and ureteral calculi in an 8 year old boy. The condition was primarily osteomyelitis of the tibia due to Staphylococcus aureus. W. Weber recently reported 3 interesting cases of nephrolithiasis following infections of the bones. The first patient had both legs amputated because of a gunshot wound of the thighs, and osteomyelitis of the stumps developed; the second had a gunshot wound of the pelvis and hip, and in the third osteomyelitis developed following an operation for genu valgum. Lepoutre reported a case of nephrolithiasis following severe war wounds necessitating amputation of the left thigh.

Grossman reported a case of lithiasis following osteomyelitis of the os calcis, clavicle and femur in a 9 year old girl. Borman recently described a case of bilateral renal and ureteral calculi in a 9 year old boy who had osteomyelitis of the left femur. Le Fur cited a case of bilateral renal lithiasis in a young man, aged 20, following an injury of the bone marrow by a bullet. Luys reported the case of a World War veteran, immobilized for an extremely long time because of serious lesions of the spinal marrow and the bodies of the vertebrae, who spontaneously voided several phosphatic vesical calculi. Barr and Charles reported 3 instances of renal calculi occurring in relation to various suppurative bone diseases: 1 in association with osteomyelitis of the right knee, left tibia, left arm and right femur in a 16 year old boy; 1 following multiple comminuted fractures of the left tibia, right metatarsal bones and right ulna and radius, complicated by osteomyelitis at the site of each fracture in a 27 year old man, and 1 following chronic otitis media with suppurative mastoiditis in a 35 year old man.

E. Joseph stated that in his experience many examinations had been made of wounded veterans in whom calculi had developed. Most of these veterans had undergone amputations of an arm or a leg, presumably for infection following bone injuries. He mentioned a case of bilateral lithiasis in a man who had bilateral amputation of the legs. He believed that the great metabolic changes brought about by the amputation in this case were the cause of the lithiasis.

In 1931 Wolf reported his observations on the formation of urinary calculi in patients who had had an amputation of a leg as a result of a war injury. Among 419 patients who had undergone an amputation above the knee joint, 4 later presented renal calculi. Among 300 patients in whom the injured leg was amputated below the knee, 1 acquired renal calculi. The author cited the fact that rats subjected to some sort of mechanical jolting at intervals for three months show hemorrhages in the urinary passages not uncommonly leading to stone formation. He believed that patients who have lost a leg, especially if the artificial leg

is too short, as it very frequently is, suffer a jolting whenever they walk and that this constant unnatural jarring of the body leads ultimately to renal stones laid down on a nucleus of fibrin.

C. K. Smith recently made a study of urinary calculi in children and noted the occurrence of multiple bilateral renal calculi in a girl of 11 years suffering from a diffuse osteomyelitis involving the lower part of the legs, the left thigh and the pelvic bones in the left sacro-iliac region. Nove-Josserand is quoted by Rafin as having recorded a case in which a renal stone was discovered on examination of the roentgenogram and recovered at operation from a child who first had a mouth infection followed by bronchopneumonia and later by grave osteomyelitis.

Lepoutre is of the opinion that there is a definite relation between osseous and osteo-articular involvements and lithiasis and has emphasized the rôle of long immobilization for such diseases in the production of lithiasis. He believes that arthritis may be a factor when the calculi are formed of urates but not when the calculi are composed of phosphates and carbonates. Calculi of the latter type are attributed to a diathesis in which there are disorders in the mobilization of minerals; some of these minerals may be deposited in the urinary passages. He called attention to the fact that the urine of patients in whom calculi develop following prolonged immobilization for bone diseases is usually alkaline, which is favorable to the formation of calculi composed of phosphates or carbonates.

W. Weber stressed the rôle of infection in the formation of urinary calculi in osteomyelitis. He stated that urinary calculi are frequently observed in those bone diseases in which an infection supervenes whether in an exogenous manner, as in complicated fractures and osteomyelitis, or in an endogenous manner, as in chronic infectious arthritis of the spinal column or in infectious arthritis of the hip, especially the bilateral form of the latter lesion.

We have observed urinary lithiasis following amputation of an extremity in 4 cases and following osteomyelitis in 2 cases.

CASE 1.—A. P., a man 58 years old, a jeweler, was admitted to Sinai Hospital on May 20, 1924, with the complaint of difficult urination. The family history was negative. His general health was good until fifteen years prior to this when he underwent an amputation of the right leg below the knee for gangrene.

Present Illness.—A year prior to hospitalization the patient began to complain of frequency of urination, nocturia, dysuria, urgency, pollakiuria and incomplete emptying of the bladder. The symptoms had increased in severity for the past three months. The patient had hematuria for the first three months before examination but subsequently on several occasions noticed clots of blood in his urine. He had had pain in his flanks and the lower part of the back off and on for the past year.

Physical Examination.—Abnormalities of interest were found on examination of the extremities and the prostate. The amputation stump of the right leg was

healed, and a pulsation was palpable in the popliteal space. Rectal examination disclosed enlargement of the prostate of the second degree; the surface presented no areas of stony hardness.

Urinalysis.—The test for albumin was positive, and microscopically the voided urine showed many pus and red blood cells, several epithelial cells and an occasional hyaline and granular cast.

Course.—On May 20 cystoscopy was performed under caudal anesthesia. Two calculi, each about the size of a walnut, were seen on the posterior wall of the bladder. There was a marked intravesical bulging of the prostate posteriorly in the form of a median lobe. On May 21 the patient was taken to the operating room, and preparation was made for performing a suprapubic cystostomy. Nitrous oxide and oxygen were administered, but the cardiac and respiratory conditions of the patient were not entirely satisfactory during the anesthesia. A soft rubber catheter was passed into the bladder and 100 cc. of air was injected through it. The usual midline incision was made; the dissection was carried down to the surface of the bladder. Another 100 cc. of air was injected into the bladder and immediately after this the patient stopped breathing, seven minutes having elapsed since the start of the anesthesia. Attempts to revive the patient were unsuccessful. The patient's sudden death was apparently due to an air embolus.

A postmortem suprapubic cystostomy was carried out in order to establish a correct diagnosis. Eighteen calculi, each the size of a small marble, were removed from the bladder. The prostate and a portion of the bladder were also removed. Further examination of the bladder disclosed marked thickening of the walls. Over the entire surface of the organ were seen many ulcerations varying in diameter from 5 to 7 mm. and grayish or greenish gray. The prostate was moderately enlarged, producing an intravesical bulging of the median and lateral lobes. The prostate was firm in consistency and on cross-section offered a gritty and rubbery resistance. Microscopic examination of several sections taken from different portions of the prostate disclosed an infiltrating carcinoma.

Diagnosis.—The diagnosis was (1) calculi in the urinary bladder, (2) carcinoma of the prostate, (3) ulcers and gangrene of the bladder, (4) thromboangiitis obliterans (left leg) and (5) amputation of the right leg for gangrene.

Case 2.—M. H., a white man 63 years old, a tinsmith, was admitted to Sinai Hospital on Sept. 9, 1932 with the complaint of frequent and painful urination. The family history was without significance. The patient had enjoyed good health until eleven years prior to hospitalization, when he slipped and fell from the roof of a two story building on which he was working. His right arm was mangled, and an immediate amputation at the shoulder joint was necessary. The wound was slow in healing owing to suppuration. The patient stated that he also sustained an injury to his head at the same time, presumably a fracture of the skull, which required operative treatment.

Present Illness.—His urinary difficulties began one year after this accident. He began to complain of diurnal frequency, nocturia, hesitancy, urgency, dysuria and weak stream. Four months prior to examination his urinary symptoms appeared to be aggravated. He suffered with pain and burning during the entire act of urination and had difficulty in starting his stream. There was no history of acute retention, hematuria or passing of calculi.

Physical Examination.—The findings of interest are recorded here. There was a linear scar, 15 cm. long, extending from the right occipital to the left parietal region. About midway along the scar there was a circular depressed area, 1.5 cm. in diameter. The right arm had been amputated at the shoulder joint. Abdominal

examination disclosed slight tenderness in the left upper quadrant over the kidney and in the left lower quadrant along the course of the ureter. Rectal examination revealed a small flat prostate of a soft and elastic consistency.

Laboratory Studies.—A voided specimen of urine showed a definite trace of albumin, and on microscopic examination many pus cells and an occasional red blood cell and hyaline cast were seen. During his stay in the hospital, his blood urea ranged between 30 and 40 mg. per hundred cubic centimeters. The Wassermann reaction of the blood was negative.

Course.—Cystoscopic examination was performed on Aug. 12, 1932 in the outpatient department. The capacity of the bladder was 250 cc., and the residual urine was 150 cc. Inspection of the bladder revealed six calculi of varying sizes lying close together. The walls of the bladder were congested and showed many cellules and trabeculations. A roentgenogram showed six calculi in the bladder,

Fig. 1 (case 2).—Roentgenogram showing multiple calculi in the bladder, two large calculi in the left kidney and a calculus in the right kidney.

two large shadows in the region of the left kidney and two small shadows in the region of the right kidney (fig. 1).

On September 9, under caudal anesthesia, a bilateral ligation and partial resection of the vas deferens was done. On September 13, under spinal anesthesia, a suprapubic lithotomy was done and the six calculi were removed. The walls of the bladder were thickened and presented numerous cellules and trabeculations. The vesical orifice showed a median bar of moderate size with no enlargement of the lateral lobe. The patient made an uneventful recovery and was discharged from the hospital on November 3.

Diagnosis.—The diagnosis was (1) bilateral nephrolithiasis, (2) median bar formation, (3) calculi in the urinary bladder and (4) amputation of the right arm at the shoulder.

Case 3.—M. S., a white man 63 years old, retired, was admitted to Sinai Hospital on May 25, 1934, complaining of hematuria. The family history was

unimportant. In 1902 he sustained a compound fracture of both bones of the right leg, which was followed by gangrene and necessitated amputation below the knee. He had been wearing an artificial leg for twenty years. Three years prior to examination a prostatic punch operation was performed for a median bar.

Present Illness.—Four years prior to examination he observed blood in his urine and experienced dull nonradiating pain in his left lumbar region, which recurred at frequent intervals. These attacks were occasionally accompanied by nausea, vomiting, chills and fever. Following the prostatic punch operation, he had diurnal frequency, nocturia, hesitancy and urgency.

Physical Examination.—The positive findings were tenderness in the left upper quadrant of the abdomen and left lumbar region. A well healed stump was present in the midportion of the right leg.

Fig. 2 (case 3).—Roentgenogram showing a calculus of the large staghorn type in the left kidney.

Laboratory Studies.—Voided urine showed albumin and contained many pus cells and an occasional red blood cell. The blood urea was normal. The result of the phenolsulphonphthalein test was 20 per cent for the first hour and 15 per cent for the second.

Course.—Cystoscopy and pyelography were performed on May 28 and revealed a calculous pyonephrosis on the left side. The calculus was of the large staghorn type (fig. 2). On June 1, nephrectomy on the left side was performed under ether anesthesia. The patient had an uneventful recovery, except for a low grade infection of the wound, and was discharged from the hospital on August 12.

Diagnosis.—The diagnosis was (1) calculous pyonephrosis on the left side and (2) amputation of the right leg.

Case 4.—D. C., a white man 48 years old, a pedler, was admitted to Sinai Hospital on Nov. 15, 1934. He had had the usual diseases of childhood and

adolescence. In 1926 he had an acute gonorrheal urethritis complicated by a urethral stricture. In August 1930 he was in an automobile accident and sustained a compound comminuted fracture of the right tibia and fibula, which became infected, necessitating an amputation of the right leg below the knee. Four months later his first attack of right renal colic developed. In July 1933 a roentgenogram of the genito-urinary tract revealed multiple calculi in both kidneys. In September 1933 the signs and symptoms of a stone in the bladder developed and he was admitted to the hospital for cystoscopic removal of the vesical calculus and transurethral resection of a median bar.

Present Illness.—Following the latter treatment the patient enjoyed good health until two months before his final admission to the hospital, when he noticed blood in his urine on several occasions. He also complained of persistent dull pain in both lumbar regions which did not radiate. There were diurnal frequency (every

Fig. 3 (case 4).—Roentgenogram showing multiple calculi in both kidneys.

two hours) and nocturia (from one to three times), but no dysuria, tenesmus or burning. There were no chills, fever, nausea or vomiting. He had noticed a progressive loss of weight, strength and appetite.

Physical Examination.—The important positive findings were mitral insufficiency and tenderness in both upper quadrants of the abdomen and in both lumbar regions.

Laboratory Studies.—The urine showed a trace of albumin and contained many pus and red blood cells. The blood urea was 65.91 mg. per hundred cubic centimeters, and the Wassermann reaction of the blood was negative.

Course.—Cystoscopy performed on Nov. 14, 1934 revealed the presence of pus in both kidneys and marked impairment in the function of each kidney. The phenolsulphonphthalein excretion from the left kidney was 3 per cent and that from the right kidney only 1 per cent in fifteen minutes. A plain roentgenogram of the genito-urinary tract revealed multiple calculi in both kidneys (fig. 3). On November 17 a nephrolithotomy was done under gas and ether anesthesia. Five

stones were removed from the left kidney, which showed advanced pyonephrosis. The patient appeared to be in a state of shock for the next twenty hours, with marked cardiac embarrassment and relative anuria. He responded poorly to the usual supportive measures and died four days after operation.

Diagnosis.—The diagnosis was (1) bilateral multiple renal calculi, (2) bilateral pyonephrosis and (3) amputation of the right leg following fracture.

CASE 5.—A. N., a white man 52 years of age, a store keeper, married, gave a history of osteomyelitis at the upper end of the right humerus at the age of 12 necessitating four operations and resulting in marked shortening of the arm. He began to have renal colic on the left side seven years ago and following cystoscopic dilatation passed a small stone. He was seen by us for the first time in June 1932 with the usual symptoms of prostatism. A prostatic resection was performed on June 15. The symptoms of prostatism returned in September 1933, and a second prostatic resection was performed on June 8, 1934. A good functional result was

Fig. 4 (case 6).—Roentgenogram showing bilateral renal calculi. The arrows point to the calculi.

obtained. On October 11 the patient had left renal colic and passed a small stone about the size of a pea. A plain roentgenogram revealed no shadows in the renal or ureteral regions.

Diagnosis.—The diagnosis was (1) renal calculus on the left (passed) and (2) osteomyelitis of the right humerus.

CASE 6.—A. J. B., 33 years old, single, white, a physician, had nothing of importance in his past history except an osteomyelitis involving the lower ends of the right radius and ulna at the age of 5 years which necessitated two operations.

Present Illness.—On April 3, 1934, a painless hematuria developed which persisted for six days. For a year he had had several attacks of sharp pain in the right upper quadrant of the abdomen and right loin radiating downward anteriorly to the right groin. A voided specimen of urine showed from 15 to 20 red blood cells and an occasional pus cell. The results of the physical examination were negative.

Course.—Cystoscopy and pyelography performed on April 10 revealed two small calculi in the left kidney and one in the midportion of the right kidney. Following dilatation of the ureters the patient passed three small stones which contained mixed phosphates. He was put on an acid ash-producing diet with a high content of vitamin A but failed to adhere to it after the first few weeks. He returned on October 10, complaining of sharp pain in the region of the right kidney accompanied by chills, fever and hematuria. A plain roentgenogram of the genito-urinary tract at this time revealed a right angle calculus in the region of the pelvis of the right kidney and a shadow about the size of the head of a match in the upper pole and a similar shadow in the lower pole of the left kidney (fig. 4). Following conservative treatment the hematuria, chills and fever promptly subsided. The same dietary restrictions have been advised.

Diagnosis.—The diagnosis was (1) bilateral renal calculi and (2) osteomyelitis of the right wrist.

INJURIES OF VERTEBRAE AND CORD

It is a well known fact that a fracture of the vertebrae with injury to the spinal column may be followed by a rapid formation of renal calculi. The earliest report of such a case in the English literature was contributed by Costello in 1833. Costello stated that Earle in a report made prior to 1833 had described several cases of lithiasis, which he attributed to a subacute inflammatory condition of the kidneys induced by injuries to the lumbar region. In 1837 Ollivier reported a case of renal calculi following a spinal injury. In 1868 Bastian found several calculi in the renal pelvis during an autopsy on a patient who had died from an injury of the spine. In 1875 Lediard cited a case of vesical calculus developing after an injury of the spine. In 1882 H. Smith reported the occurrence of a vesical calculus after an injury of the spine which resulted in a paralysis of the lower half of the body. In 1884 Puzey reported a case of renal calculi following a fracture of the spine. In 1887 Maschka reported 3 cases of renal lithiasis following compression of the spinal cord; 2 were associated with tumors of the vertebral column and 1 followed a fracture of the vertebrae. Benda noted a number of cases of extensive formation of renal calculi in a series of 50 autopsies on soldiers who died of gunshot wounds of the spinal cord.

In the German literature the relation of injuries of the vertebrae and cord to renal lithiasis was first stressed by Bramann in 1891. In 1895 Müller reported the occurrence of bilateral nephrolithiasis in 8 of 10 cases of severe injuries of the spinal column. He explained the occurrence of renal calculi in these cases on the basis of a simultaneously existing injury of the kidney itself. In 1896 Kocher reported a case of vesical calculus in a man with a healed compression fracture of three dorsal vertebrae. In 1897 A. Weber observed a case of bilateral renal calculi in a young man, 19 years old, after a fracture of the vertebrae

resulting from a fall on the back. In 1898 Wagner and Stolper reported a case of nephrolithiasis following a fracture of the fourth thoracic and first lumbar vertebrae accompanied by complete transverse destruction of the cord in a man 35 years old.

In 1895 Müller stated that a study of the literature shows that stone formation in the kidneys occurs in about 10 per cent of the cases of fracture of the vertebrae when this is accompanied by paralytic symptoms. The incidence of stone formation following such injuries appears to be greater in males. The length of time required for the formation of renal calculi following such injuries is variable, but usually from three to six months elapse before symptoms of renal colic are manifested. Frequently in these cases the presence of urinary calculi is unsuspected and the diagnosis is made from roentgenographic findings during further studies of the bone injury. However, O'Conor reported a case of renal and vesical calculi confirmed by a roentgenogram taken four weeks after the primary injury and three weeks after the onset of urinary infection. There was a total absence of any previous history suggesting their presence. In Seefisch's case, the patient began to have renal colic eight weeks after the spinal injury, and the diagnosis of renal calculi was confirmed at that time by a roentgenogram.

Young and Waters reported a case of renal stone formation following a fracture of the first and second cervical vertebrae in a 17 year old patient. The lesion of the cord resulted in paralysis of the bladder with infection of the upper urinary tract. Eisendrath cited a case of a large branched calculus in a kidney with complete loss of function of the affected organ occurring five years after a fracture of the spine. Cahill reported a case of recurrent calculus formation in a young man following a fracture of the lower dorsal region of the spine. This patient had a decompression at the site of the fracture. Urinary retention, infection and bilateral pyelitis developed. Young mentioned the case of a young officer whose spinal cord was severed by a machine gun bullet. Marked urinary infection developed with multiple calculi in the renal pelves, ureters and bladder.

E. Simon reported the case of a man aged 34 years in whom renal calculi developed as a result of an injury to the spinal cord and fracture of the lumbar vertebrae resulting from a fall from a high scaffold. Conwell reported 100 cases of vertebral fractures without injury of the cord among which he observed 8 cases with renal calculi, viz., 5 following fracture of lumbar vertebrae and 3 following fracture of dorsal vertebrae. Harper, Wallenstein and Cumming recently reported several interesting instances of renal lithiasis following fractures of the cervical and lumbar vertebrae. Haumann reported 5 cases of calculous pyonephrosis developing after transverse myelitis which ended fatally

and 1 case following fracture of the thoracic vertebrae with total paralysis of the legs, bladder and rectum. The cases reported by Geldmacher and Meyer are of special interest as the vertebral injury was followed by the so-called myositis ossificans neurotica in addition to the formation of renal calculi. Barr and Charles observed the development of myositis ossificans neurotica and renal calculi in a man 55 years old who had an extensive destructive process of the second and third lumbar vertebrae with sharp angulation associated with secondary hypertrophic changes in the vertebrae. The destructive process in the vertebrae was attributed to a chronic osteomyelitis or tuberculosis which followed a violent injury at the age of 14 when a machine weighing 125 pounds (56.7 Kg.) fell 9 feet (about 3 meters) and struck the middle of his back.

There are many factors concerned in the formation of renal calculi after injuries of the vertebrae and cord. The most important consideration is the condition of the kidney before and after the accident. The existence of a lesion of the upper urinary tract antedating the spinal injury must always be borne in mind and carefully excluded as a causative factor. Confirmatory evidence of the development of a renal lesion in every case of renal lithiasis following a spinal injury is found in the impaired renal function and alterations of the urinary constituents.

In some cases the formation of calculi is dependent on a primary intrinsic lesion of the kidney, i. e., a rupture or tear of the renal parenchyma with extravasation of blood into the renal pelvis which occurs at the time of the injury to the vertebrae and cord. This view has been upheld by Müller, A. Weber and Wagner and Stolper. Casper showed that blood clots and new connective tissue may form in the renal pelvis or in the parenchyma as a result of trauma and serve as a nucleus for stone formation. In these cases the stones are usually of the oxalate or urate variety.

Oehlecker classified traumatic calculi into two groups: (1) the directly posttraumatic calculi (so-called genuine traumatic calculi) associated with a direct injury to the kidney following which small blood coagula, fibrin floccules, clumps of bacteria or products of inflammation act as the centers for the formation of calculi, and (2) the indirectly posttraumatic calculi which form after an injury to the spine with associated paralysis of the bladder or of the entire urinary tract. He pointed out that calculi are relatively uncommon after direct trauma to the kidney inasmuch as it is an exceedingly rare complication of the most common type of traumatic injury, i. e., operations on the kidney. He maintained that the blood clot which accompanies or follows an injury to the kidney does not alone suffice to explain the formation of calculi since the clot is often changed or even absorbed

while the stone forms, but that there must be, in addition, a disturbance of the colloid-crystalloid equilibrium of the urine with resultant precipitation of the urinary salts about a central nucleus or framework of red blood cells or fibrin in a blood clot. The calculi which develop after an acute trauma to the kidney are more loosely constructed than an ordinary laminated stone, and often a transverse section of a true traumatic calculus shows a small central cavity which is due to a resorption of the blood clot.

Oehlecker recently reported an interesting case of stone formation following a fracture of the third lumbar vertebra with avulsion of the transverse processes of this vertebra in addition to other severe bone fractures. Block reported a case of renal calculi developing in a man 33 years old after an injury to the cauda equina associated with paralysis of the bladder which followed a fall from a scaffolding for a distance of 23 meters. Simon reported an interesting case of a wounded aviator whose left kidney was shattered through a machine gun injury and who at the same time sustained a fracture of the first and second lumbar vertebrae. The left kidney was removed immediately. Subsequently calculus formed in the other kidney, and thirteen years later he succumbed to anuria.

Lesions of the kidney following spinal injuries are the result of paralysis of the bladder, ureter and renal pelvis. Holländer explained the bilateral formation of renal calculi following injuries of the cord on the basis of an interruption of the reflex arc concerned in the expression of urine from the renal papillae into the renal pelvis. He maintained that there is a loss of muscular activity in the renal pelvis and ureter, so that instead of the action as of an aspirator and pressure pump in the passage of urine from the renal papillae to the bladder, there is a slowing of the outflow of urine. This derangement of the nervous mechanism of the bladder, ureter and renal musculature favors urinary stagnation and infiltration with a resulting cystopyelitis or pyelonephritis. Secondary changes in the urine soon occur, i. e., decomposition and ammoniacal fermentation of urinary salts with ultimate formation of phosphatic calculi. Seefisch stressed the rôle of infection of the urinary passages in the formation of calculi following spinal injuries. The process involved in renal lithiasis following vertebral injuries has been considered by some workers to be similar to that in the formation of gallstones. Kocher believed that the increased elimination of calcium salts following spinal injuries is the cause of the formation of calculi. Haumann maintained that vasomotor paralysis is the chief factor in cases of calculi associated with transverse myelitis. The vasomotor paralysis causes hyperemia in the paralyzed parts and simultaneous anemia in the kidneys. Consequently, epithelial cells are shed by the

kidney forming a center for precipitation of calcium salts and especially phosphates.

Zondek stated that the stones seen after injuries of the spine are always particularly rough and irregular. He suggested that when such shadows are found in a roentgenogram of the kidneys the possibility of an antecedent spinal injury should be ruled out.

It is interesting to note that Rosenstein recently reported a case of bilateral renal lithiasis developing after a gunshot injury of the brain, which is apparently without an analogy in medical literature. In a case that we observed there was a history of fracture of the skull associated with a mangling injury to the right arm which was followed by the formation of calculi in the bladder and both kidneys. Thorn reported a case of recurrent calculus in a paraplegic patient.

The presence of calcium stones following injuries of the vertebrae and cord has been attributed to the absorption of calcium from the surfaces of the fractured vertebrae and from the long bones of the extremities, as manifested by the high degree of bone atrophy in these cases. The immobilization of the body following fractures of the spine favors such absorption, as emphasized by Lepoutre and Schwarz. Various authors have stressed the danger and influence of catheterization and cystostomy on the development of urinary infections and subsequent formation of stones in these cases.

The true significance of the tendency to deposition of calcium after vertebral fractures as a result of the disintegration of calcium salts remains as yet unexplained, as evidenced by the different conceptions of the authors cited. However, new information which may have a bearing on the question of the elimination of calcium through the kidney and its deposition in the renal pelvis or parenchyma has been contributed by Hess and his associates. They found that a marked rise and disturbance in the equilibrium of the calcium in the blood were brought about by section of the spinal cord in the upper dorsal segment. They also noted that the equilibrium of the calcium and the phosphorus in the blood serum was rendered less stable by division of the sympathetic or parasympathetic nerves.

Trosler recently submitted a clinical report of 19 cases of fracture of the transverse processes of the vertebrae producing symptoms simulating those referable to the kidneys. None of the patients showed evidence of renal calculi on roentgen examination.

FRACTURES AND TUMORS OF THE BONY PELVIS AND LONG BONES

The development of urinary calculi following fractures of the bony pelvis and of the long bones is perhaps a more common occurrence than a review of the literature would lead one to believe. A natural reluctance

on the part of urologists to report such isolated cases may account for the decided paucity of recorded observations.

Fractures of the bony pelvis are frequently accompanied by infection of the urinary tract. The infection may develop as a result of an associated injury of the bladder or urethra or as a result of the inactivity and lowered resistance accompanying the prolonged immobilization for the bone injury. The infection is usually present in the form of an ascending cystopyelitis. Noland and Conwell recently noted the apparent tendency toward infections of the urinary tract with formation of renal and vesical calculi during the convalescent period in several cases of severely fractured pelves. Young and Waters, Cabot and Braasch and others have reported cases of urinary calculi following fractures of the pelvis.

The development of urinary calculi following fracture of a long bone, i. e., the femur, tibia, fibula, humerus, etc., is relatively infrequent. The exact etiologic relationship between the fracture and the urinary lithiasis is not definitely established. Bonneau and W. Weber reported cases of fracture of the long bones of the leg complicated by the formation of urinary calculi.

Wilson recently reported an interesting series of cases of renal colic and hematuria following recumbency for fracture of a femur. Of 150 patients treated by the Sinclair method, 23 (15 per cent) had renal colic. Most of the patients concerned were kept recumbent for a long time on account of severe wounds, prolonged sepsis and delayed union or nonunion. It was strikingly noticeable that in nearly all the cases renal colic and hematuria occurred suddenly on the first and second days after the patient got up and that the patient just as quickly got well again without fever, rigors or other trouble up to two and a half years afterward. In only 1 of the 23 cases was there evidence of calculus formation. The patient was a badly wounded man with an additional gunshot wound of the hip joint and was on his back for a long period with persisting local sepsis.

We have been unable to find in the literature any report of an association of urinary calculi with a tumor of the bony pelvis or a long bone with the exception of Jeck's case. He reported a case of multiple enchondromas involving the pelvic bones, femurs, tibia, fibula, radius and ulna of a male Negro 40 years old, which was complicated by calculi in the bladder.

Peterson reported some interesting observations on the calcium-phosphorus balance during the healing of fractures which may offer a solution to the problem. He noted a definite rise in the calcium-phosphorus product during the healing stage in the usual case of fracture. On the other hand, he found a reduction in this product in

those cases in which nonunion resulted, mechanical factors having been excluded. When the calcium-phosphorus product was below 30 the bones did not unite. When the product was between 30 and 35 there was little healing, but when it was between 35 and 40 the healing was very active. Thus one may infer that the metabolism of calcium and phosphorus is altered following a fracture of any long bone. Although Peterson's work appears to have been generally accepted, liberally quoted and literally interpreted, Speed failed to confirm these findings after studying several hundred observations on the blood serum calcium and phosphorus in a consecutive series of patients with fractures.

If these changes in the metabolism of calcium and phosphorus, however slight, are accompanied by faulty elimination through the kidney renal calculi may develop. The impaired renal function may be the result of a disease of the kidney antedating the fracture. A contributory factor may be the development of a renal infection during the period of immobilization for the fracture. Such an infection frequently occurs in elderly patients.

CASE 7.—R. S., a white woman 52 years old, married, a housewife, was admitted to Sinai Hospital on July 30, 1928, with a complaint of pain in the left side of the abdomen. She had always enjoyed good health until in December 1924, when she fell and sustained a fracture of the right femur. She began to have renal colic on the left side in March 1925 and again in May 1925. She was examined in August 1925, and a small calculus was found in the ureter. She thinks she passed this stone. Since December 1924 she has been using crutches to aid her in walking.

Present Illness.—About one week prior to examination she had a severe attack of renal colic on the left side, which lasted several hours and was relieved only after a hypodermic injection of morphine. The attack was accompanied by nausea, vomiting, chills and fever. There was diurnal and nocturnal frequency but no burning, dysuria, intermittency or hematuria.

Physical Examination.—A deformity was present in the right thigh due to an overriding of the fragments. There was definite tenderness in the left lumbar region and in the left upper quadrant of the abdomen.

Laboratory Studies.—A voided specimen of urine was negative for albumin and sugar but showed a few pus and red blood cells. The blood urea was 32.9 mg. per hundred cubic centimeters.

Course.—Cystoscopic and pyelographic studies revealed a small calculus the size of a pea at the junction of the middle and upper third of the left ureter. Several dilatations of the ureter were performed and the patient passed the calculus. She underwent an operation for realinement of the displaced ends of the right femur in the spring of 1929. There has been no further recurrence of the urinary symptoms.

Diagnosis.—The diagnosis was (1) left ureteral calculus and (2) fracture of right femur.

CASE 8.—C. R., a white man 50 years old, married, a machinist, was seen for the first time on Dec. 13, 1933, complaining of pain in the left lower quadrant of the abdomen. About ten weeks prior to this the patient sustained a compound

fracture of both bones of the left leg in an automobile accident. He was confined to bed for eight weeks and for three weeks had been walking with crutches.

Present Illness.—Four days before examination he had a sudden sharp pain in the left lower quadrant of the abdomen which radiated up to the left lumbar region and to the umbilicus. The pain lasted several hours, and morphine was required for relief. He had a similar attack on each of the following days. There were no urinary symptoms.

Physical Examination.—The positive findings were tenderness in the left lumbar region, the left upper quadrant of the abdomen and the suprapubic area.

Laboratory Studies.—A voided specimen of urine revealed only an occasional pus cell.

Course.—Cystoscopy and pyelography were performed on Dec. 31. Plain and stereoscopic roentgenograms with the catheter in the left ureter showed a small calculus in the lower third of the ureter. A left ureteropyelogram revealed a normal pelvis with a slight dilatation of the ureter above the stone. When the left ureteral catheter was withdrawn a small calculus, the size of the head of a match, was drawn into the bladder. This calculus was removed five days later. The patient has subsequently been free from symptoms.

Diagnosis.—The diagnosis (1) was left ureteral calculus and (2) compound fracture of the left leg.

CASE 9.—F. H. K., a white man 45 years old, married, was first seen on Aug. 8, 1933, complaining of pain in the left side of his back. In 1896 he sustained a fracture of both bones of the left leg as a result of a horse stepping on his leg, and in 1908 he incurred a similar fracture in an automobile accident. Following the latter injury he walked with a decided limp.

Present Illness.—One year prior to examination he began to have renal colic on the left side, which was followed by expulsion of a small stone. He had recurrent attacks of sharp pain in the left lumbar region which occasionally radiated to the left groin. He also complained of burning, urgency, frequency, etc.

Physical Examination.—The results were negative except for slight tenderness in the left lumbar region and a first degree enlargement of the prostate. A voided specimen of urine showed only a few pus and red blood cells.

Course.—Cystoscopy was attempted on Aug. 8, 1933, but was impossible owing to an obstruction at the vesical orifice. Intravenous urography revealed a normal renal pelvis on the right and mild hydronephrosis and hydro-ureter on the left. No stones were visible in the kidneys or ureteral regions. After several dilatations of the vesical orifice, cystoscopy and pyelography performed on December 20 revealed marked stenosis of the vesical orifice, two vesical diverticula and hydronephrosis on the left. The patient was admitted to the hospital, and the vesical diverticula and the prostate were removed in a two stage suprapubic operation. The convalescence was uneventful. However, the pain in the left lumbar region persisted. On June 16, 1934, a plain roentgenogram revealed a small shadow on the left side opposite the transverse process of the second lumbar vertebra. Several days later the patient passed a small stone.

Diagnosis.—The diagnosis was (1) left ureteral calculus (passed), (2) old fracture of the left tibia and fibula, (3) benign hypertrophy of the prostate and (4) left hydronephrosis.

CASE 10.—This case is reported through the courtesy of Dr. John Hogan. H. T., a white girl aged 9 years, sustained a fractured pelvis in June 1932. In

July 1934 she was admitted to the hospital, complaining of pain of four months' duration in the left side of the abdomen. An appendectomy was performed. Following the operation the pain persisted, and the patient was readmitted to the hospital on September 24. There were no urinary symptoms.

Physical Examination.—The positive findings were tenderness in the left lower quadrant of the abdomen and the left lumbar region. The urine showed a slight trace of albumin and an occasional red blood cell.

Course.—A plain roentgenogram of the genito-urinary tract showed a small irregular shadow opposite the ischial spine on the left side. The presence of a stone in the left ureter was confirmed by cystoscopy (fig. 5). Intravenous urography showed normal kidneys and pelves. On the third day following cystoscopy, she passed a calculus.

Diagnosis.—The diagnosis was (1) left ureteral calculus and (2) fractured pelvis.

Fig. 5 (case 10).—Roentgenogram showing a calculus in the left ureter, indicated by *A*, and the site of an old fracture in the ischium, indicated by *B*.

OSTEITIS FIBROSA CYSTICA

Osteitis fibrosa cystica, often spoken of as osteitis fibrosa, is also more common than is generally supposed. The essential features were first described by von Recklinghausen in 1891; hence the disease frequently bears his name.

The disease is more frequent in females and is encountered in childhood and adolescence. Although the majority of the cases occur in patients under 20, cases have been reported which occurred in adults and elderly people. The onset is insidious, usually painless, the disease producing few early symptoms. Attention is first called to the disease by the occurrence of a spontaneous fracture or fracture following an unusually slight injury. The long bones are the most common site of

the lesion, and in the order of frequency of involvement one notes the humerus, femur and tibia. The jaw, skull and pelvis may also be involved.

Two types of the disease are recognized, i. e., a localized and a generalized type. The localized form may be accompanied by a benign bone cyst and is dependent on trauma in the majority of instances. The generalized form is dependent on grave nutritional or metabolic disturbances. Dysfunction of endocrine glands, faulty calcium metabolism and chronic infection of a low grade appear to have some etiologic significance. A striking relationship exists between osteitis fibrosa cystica and tumors of the parathyroids.

The disturbed calcium metabolism in this disease was first described by Jacoby and Schroth and was later observed by Dawson and Struthers, Huepner, and Hubbard and Wentworth. Jacoby and Schroth found an abnormally high excretion of calcium, which they thought could be remedied by administration of calcium lactate. Mandl, Gold, Wilder, Boyd and others have also noted the increased excretion of calcium in the urine which is reduced after operative removal of an associated parathyroid tumor. Studies of the calcium in these patients usually revealed hypercalcemia. The calcium content of the serum ranged from 12.8 mg. per hundred cubic centimeters in Snapper's case. A co-existing hypophosphatemia has also been observed in several cases.

Calcium stones in the upper urinary tract have been reported in several cases of osteitis fibrosa cystica. Gaugele's patient, a woman aged 37, died of uremia, and at autopsy the kidneys were found to contain sand and stone which had caused hydronephrosis and pyelonephritis. Stones were also present in the ureter. In the case presented by Hoffheinz, calcium infarcts as well as a large coral stone in the upper calyx of the right kidney were found.

OSTEOMALACIA

Osteomalacia is a chronic disease of the bones and is frequently known and described as fragilitas ossium and as osteoporosis. The disease is most frequently seen in pregnant women, especially at the puerperium or at the height of reproductive activity in the third decade.

The bones are soft, the consistency varying from that of wax to that of wet paper, according to the loss of mineral constituents. The bones show many deformities and often present old or new fractures. On section, a reduction of the compact and cancellous tissue with cavity formation is noted in addition to changes in the marrow of a hemorrhagic or lymphoid nature.

In the cases reported there was an obvious lack of mineral elements in the food due to the absence of vegetables, cheese, fish, butter, eggs, rice and meat, all of which are normal sources of calcium and phosphorus. With such dietary deficiencies the vitamins are necessarily reduced. Softening of bones has long been known to occur experimentally in animals with defective nourishment. Van Saceghem also noted its occurrence in various animals in the Belgian Congo where the water is lacking in calcium and phosphorus.

Miles and Feng studied osteomalacia in females in China whose diets were deficient in fat-soluble vitamins and described deformities similar to those of rickets. They found that the calcium of the blood serum was greatly reduced, varying between 5.8 and 7.5 mg. per hundred cubic centimeters, the normal value being from 10 to 11 mg.

In the literature there are very few references to the occurrence of renal calculi in cases of osteomalacia. The development of urinary calculi in association with osteomalacia was pointed out by Steibel and Senator. They believed that in this disease the inorganic salts of the bone are removed and eliminated in especially large quantities in the urine. The earliest report was that by Solly in 1844. He found a large calculus of calcium phosphate in the kidney of a woman 39 years old who had died of generalized osteomalacia. He explained the formation of calculi on the basis of the absorption of the earthy matter of the bones and its excretion through the kidney in such abundance that it clogged the pelvis and calices. In 1864, Durham reported a case of mollities ossium (osteomalacia) in a woman, aged 49, whose kidneys were found at autopsy to be apparently normal except that one contained a small calculus in a pouch connected with its pelvis.

Dereux cited the case of a young woman, aged 17, who had suffered from infantile osteomalacia and in whom calculi were discovered in the bladder and kidneys on roentgen examination. Bouley is quoted by Dereux as having seen cases of renal calculi associated with osteomalacia.

OSTEOGENESIS IMPERFECTA AND OSTEOPSATHYROSIS

Osteogenesis imperfecta is a rare systemic disease of the bones. The disease is characterized by an imperfect development of the osseous systems as evidenced by stunted growth, a deformed skull and frequent fractures with excessive callus formation. There is a marked loss of calcium and phosphorus from the bones. Some attribute this derangement of calcium metabolism to a dysfunction of the endocrine glands, especially of the thymus and parathyroids. "Osteopsathyrosis" is the name applied by Lobstein (1883) to various types of bone fragility some of which are identical with osteogenesis imperfecta and others of which for a long time were incorrectly considered as osteomalacia or rickets.

In a careful perusal of the literature we could not find any record of the occurrence of renal calculi in association with osteogenesis imperfecta and only an occasional report or reference to their occurrence with osteopsathyrosis. The disturbances in calcium and phosphorus metabolism occurring as a result of the bone lesions in these diseases would favor the formation of renal calculi.

Taterka and Dinkin recently reported a case of nephrolithiasis associated with osteopsathyrosis in a man 41 years old. In a later discussion of this case Dinkin stated that there was a disturbance of hormonal equilibrium with a resultant disturbance of mineral metabolism which was favorable to stone formation.

RICKETS

In the past ten years remarkable progress has been made in the diagnosis and treatment of pathologic conditions of the urinary tract in children. With the increasing attention of physicians and surgeons to these conditions and the perfection of urologic technic, i. e., roentgenography, cystoscopy, retrograde and intravenous pyelography, etc., many of the hitherto baffling urologic conditions in children are now correctly diagnosed and properly treated.

The association of various infectious diseases with urinary calculi in children was definitely established by H. Joseph. He also reported 6 cases of rickets in which urinary calculi were observed. In these 6 cases, 4 were bilateral and 2 unilateral (both in the right kidney). W. Weber, Brown, Taterka and Dinkin each reported a case of urinary calculus associated with rickets.

In the literature one finds an occasional reference to the etiologic relationship between rickets and urinary calculi. Federoff and Rubritius attributed the formation of calculi in cases of rickets to the occasional increase of mineral salts in the urine.

A rather ingenious but plausible explanation for the development of renal calculi in rickets is offered in an editorial in the *Southern Medical Journal* (**21**: 162 [Feb.] 1920): The relation of the acid-base balance of the intestinal tract to the deficient assimilation of calcium and phosphorus in rickets is particularly stressed. It is pointed out that an alteration in the acid-base balance of the intestinal tract in rickets may be accompanied by a comparable acid-base disturbance in other tissues of the body, especially in the bladder and kidney, which may interfere with the normal excretion of phosphorus and calcium and favor stone formation.

Undoubtedly, many of the cases of renal lithiasis in children and young adults will reveal antecedent rickets if care is exercised in obtaining an accurate history. This interrelationship has not been emphasized

strongly enough. In the treatment of these conditions careful attention should be paid to the diet. The diet should contain adequate amounts of milk, cream, butter, fresh fruits and vegetables, as not infrequently the diet of children is a mildly rachitic one. The importance of a sufficient amount of vitamins A and D in the diet in the prevention of renal calculi and urinary infections is borne out by the work of Fujimaki, McCarrison and van Leersum.

TUBERCULOSIS OF THE BONES AND JOINTS

The presence of renal calculi following or during a suppurative tuberculous lesion of the bone may be dependent on the development of a tuberculous renal lesion. This may be a nephrosis accompanied by faulty elimination of inorganic salts or a tuberculous nephritis which may subsequently undergo caseation and abscess formation with frequent bacilluria. The renal calculi may develop as a result of stasis and infection of the urine secondary to the immobilization and infectious process which accompany the bone lesion. A contributing factor may be a faulty elimination of the mineral salts which are altered by the bone lesion. However, there are frequent references in the literature to renal calculi occurring in tuberculous kidneys. Liebermeister found tubercle bacilli in renal calculi and stated that the coincidental occurrence of a tuberculous lesion of the kidney and renal calculi is more frequent than is generally believed.

Mayet reported a case of bilateral renal lithiasis in a 7 year old boy who had suffered with Pott's disease of the spine. He also reported a second case occurring in a girl, aged 14 years, who had a tuberculous hip with an abscess which was aspirated. She had been treated by immobilization for two and one-half years when she was seized with an attack of renal colic and passed a small calculus. Iselin reported the case of a patient, aged 30 years, from whom, following twenty-two months of immobilization for a tuberculous knee, a uric acid calculus in the right kidney was removed by pyelotomy. Mayet believed that the formation of such calculi in cases of tuberculosis of bones or joints is secondary to renal tuberculosis and considered the immobilization for the spinal disease and the ingestion of excess phosphates as contributory factors.

W. Weber observed the formation of a calculus in a patient 19 years old who had been treated for left tuberculous coxitis. In the discussion of Weber's paper, Grossman reported the occurrence of urinary calculi in 6 cases of tuberculosis of the hip and in 3 cases of Pott's disease of the spine. Lepoutre reported a case of bilateral nephrolithiasis developing in a man 25 years old who had been under treatment for twenty-one months for Pott's disease of the spine and arthritis of the

left knee and toes which required long immobilization. He also observed another case of bilateral nephrolithiasis in the course of a tuberculous lesion of the spine.

Grunert and Berger recently observed the formation of renal calculi in 12 of 250 patients with chronic inflammatory osseous lesions, 10 of whom were tuberculous. Young reported a case of long-standing complete destruction of a kidney due to calculi in a young man complaining of a sinus in his left lumbar region. Unfortunately, the patient had undergone a previous operation for supposed tuberculous disease of the spine, and the sinus discharged a seropurulent material.

Case 11.—M. V., a woman aged 41, single, was first seen in the outpatient clinic of Sinai Hospital on May 22, 1928, with a complaint of pain in the right upper quadrant of the abdomen and indigestion. The family history was negative except that there was a definite history of tuberculosis in her paternal relatives. One cousin and a paternal aunt with whom the patient had some contact had pulmonary tuberculosis. At the age of 18 months the patient fell and injured her right hip. At the age of 8 years she was admitted to Johns Hopkins Hospital and an operation was performed on her right hip for a tuberculous infection of the joint. Between 1920 and 1929 she had several operations for tuberculous osseous lesions. In 1925 she had thirteen cystoscopic treatments. During this time several calculi were passed. She had been using crutches for the past fifteen years.

Present Illness.—The patient was referred to our clinic for cystoscopic treatments. She was suffering from diurnal frequency and nocturia. There was no definite history of renal colic or hematuria. She also complained of sharp pain in the right upper quadrant of the abdomen radiating upward to the right shoulder and occasionally toward the right shoulder blade. Her appetite was poor, and at times there were nausea, vomiting, belching and constipation. There were no clay-colored or tarry stools at any time. Her menstrual periods were always normal in regard to periodicity, flow and pain.

Physical Examination.—At the time of her admission to our clinic in May 1928 examination disclosed the following positive findings: She was of short stature, fairly well nourished and obviously deformed. She had marked scoliosis of the lumbar spine to the left with a tilting of the pelvis to the right. There was complete ankylosis of the right hip with only partial motion in the left hip (fig. 6*A*). The abdomen was full and round with tenderness in the right upper quadrant on deep palpation.

Course.—Cystoscopic studies revealed bilateral ureteral strictures with an accompanying moderate hydronephrosis on each side. There was no evidence of renal or ureteral calculi. There were no signs of tuberculosis on cystoscopic and pyelographic studies. Examinations of the urine, cultures and guinea-pig inoculations gave no evidence of the presence of tubercle bacilli.

She was then lost sight of and we next learned that she had a cholecystectomy performed in the latter part of 1929 at another hospital. She also had an exacerbation of the trouble in her right hip in the fall of 1930 which required incision and drainage, and she was confined to bed for one month. Two months later she began to complain of sharp colicky pain in the right lumbar region radiating to the groin and accompanied by frequency, urgency, dysuria and a burning sensation

on urination. Cystoscopic and roentgenographic examination revealed a stone in the lower third of the ureter which produced a scratch on a wax-tipped catheter (fig. 6*B*). After one dilatation of the right ureter (no. 10 French) the stone was passed. A roentgenogram taken in August 1932 revealed a small stone in the right kidney. At present the patient is confined to a sanatorium because of active pulmonary tuberculosis.

Fig. 6 (case 11).—*A*, marked deformity of the pelvis with rotation of the lumbar portion of the spine due to an old tuberculous process in both hip joints. Rarefaction of both ilia may be seen. There is absence of the head of the right femur with fixation of the upper end of the femur above the acetabulum. *B*, essentially the same bony changes as in *A*. The shadow seen above the tip of the catheter is a calculus in the lower third of the right ureter.

Diagnosis.—The diagnosis was (1) right renal calculus, (2) pulmonary tuberculosis and (3) tuberculosis of both hip joints.

ARTHRITIS

There have been many descriptions of varieties and phases of arthritis and also many classifications of the types of arthritis based on clinical, etiologic or other factors. However, the recent classification of arthritis based on pathologic changes as advocated by the English investigators appears to be most practical. Arthritis has been conveniently classified by Jones into the following subgroups: rheumatoid arthritis and osteo-arthritis.

There are few reports in the literature concerning the occurrence of urinary lithiasis in arthritic patients. We have so frequently detected evidences of an infectious arthritis of the spine or hip joints during the course of roentgenographic studies of urolithiasis that we believe that they have a greater significance than that of mere coincidence.

One cannot fail to recognize the fact that a close relationship may exist between the two conditions as in some instances the same etiologic factor is involved in the production of both conditions. Urinary calculi developing in patients whose arthritis is the result of a genito-urinary lesion may be a coincidental finding with no direct relation to the arthritis. In such cases, the stone formation is or may be purely dependent on a lesion of the urinary tract. However, when arthritis results from a focus of infection in any part of the body other than the genito-urinary tract the organism producing the arthritis may also set up a urinary infection with subsequent formation of stone.

W. Weber and Payr are of the opinion that chronic infectious arthritis of the spine and that of the hips are diseases of the osseous system which show a particular tendency to lithiasis. Weber reported a case of nephrolithiasis occurring in a patient suffering from infectious arthritis of the hips. Roentgen examination disclosed the shadows of several calculi in the left kidney. Barr and Charles stated that they had observed renal calculi in 10 cases of osteo-arthritis of the spine. They also reported renal calculi in a 17 year old boy with proliferative arthritis of the joints of the hand, wrist, elbows and knees and in a 32 year old Negro with extensive destruction of the hip joint (Charcot's joint) and osteo-arthritis of the spine. A case report of ours is as follows:

CASE 12.—This patient was referred by Dr. M. B. Levin. H. B., a man 72 years old, married, a retired merchant, was seen for the first time at home on Oct. 3, 1932, complaining of frequency of urination. The family history was essentially negative except that his mother had died of intestinal carcinoma. He had pneumonia as a child and malaria at the age of 16 years. He had been treated for "rheumatism" and arthritis for the past twenty years. For the past few years he had received treatment for various foci of infection, which included diathermic treatment of the tonsils, removal of infected teeth, a nasal and a sinus operation. He stated that fifteen years ago he had renal colic but did not recall on which side the pain occurred. He passed a stone from his bladder thirty years ago.

Present Illness.—The onset of the present trouble dated back several months. He began to complain of frequency, urination occurring every hour during the day and three or four times at night, difficulty in starting his stream, straining, urgency, burning and intermittency. On two occasions in the past three months, acute retention of the urine developed and he had to be relieved by catheterization. He had chills and fever at irregular intervals in the past few weeks. He also complained of pain in both lumbar regions, more marked on the right than on the left side. The pain at times had been sharp, but for the past week had been dull and persistent. He occasionally had a dull pain in the suprapubic region.

The patient had been confined to bed for the past five years because of inability to move his lower extremities. He complained of pain in practically every joint in his body. His ankles, knees, elbows and wrists were markedly enlarged, swollen and tender. He stated that his arthritis was becoming progressively worse.

Physical Examination.—The patient was a very stout, obese male. He was unable to stand because of the pain from pressure attending movements of his joints. His head was markedly enlarged. There was a deformity of the elbows, wrists and joints of the fingers. The abdomen was very obese. Neither kidney was palpable. There was slight tenderness in the right lumbar region but no tenderness over either kidney or ureter anteriorly. Rectal examination disclosed benign hypertrophy of the prostate, of the first degree.

Laboratory Studies.—A voided specimen of urine was acid in reaction and had a specific gravity of 1.020. Tests for albumin and sugar were negative. Microscopic examination revealed many pus cells and red blood cells.

Course.—A plain roentgenogram of the genito-urinary tract revealed a shadow the size of a walnut in the region of the bladder. Under caudal anesthesia, the vesical calculus was crushed and removed. Two weeks later the patient returned, complaining of pain in the region of his right kidney following an automobile ride. A roentgenogram of the genito-urinary tract revealed a shadow the size of a lima bean in the region of the lower part of the right ureter (fig. 7 *A*).

Roentgen studies of the skull, pelvis and spine were made and showed the typical osseous changes of Paget's disease (fig. 7 *B*).

Diagnosis.—The diagnosis was (1) vesical calculus, (2) right ureteral calculus, (3) arthritis deformans and (4) Paget's disease.

The evidence concerning the occurrence of a disturbance in the calcium metabolism is conflicting. In 1894 von Noorden and Belgardt and in 1910 Hofmeister found some evidence of a negative calcium balance in a small number of cases of osteo-arthritis. In 1904 McCrudden found a marked negative calcium balance in cases of atrophic arthritis, and a positive balance in cases of hypertrophic arthritis. However, a number of investigators using the newer and improved quantitative methods for the determination of calcium in small amounts of blood are still at variance in regard to the presence or absence of hypercalcemia.

Reports of hypercalcemia in arthritis have been contributed by several investigators. Weill and Guillaumin, in their study of a series of 11 cases of chronic arthritis, reported serum calcium values ranging from 11 to 17.8 mg. per hundred cubic centimeters as compared with the

normal values of from 9 to 11 mg. Watchorn likewise found the serum calcium slightly elevated in chronic arthritis. Horowitz found values as high as 16.2 mg. in 5 of 14 cases of arthritis with severe deformities. Mark reported 4 cases in which the calcium values for the whole blood ranged from 13.3 to 20.3 mg.

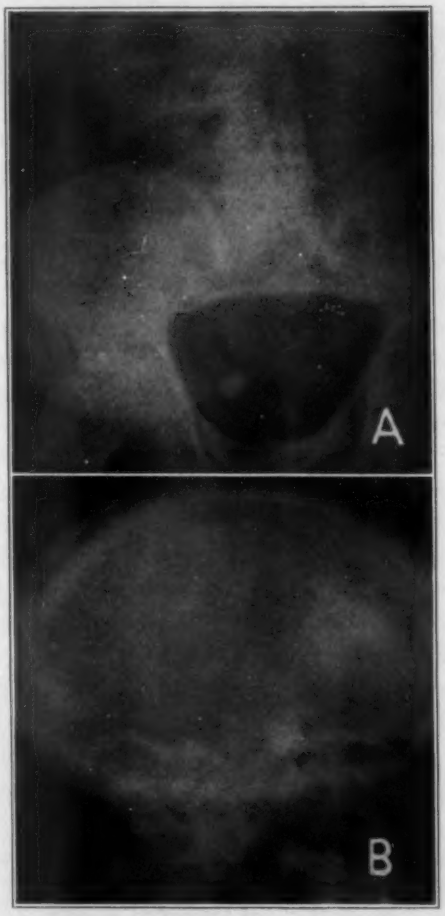

Fig. 7 (case 12).—*A*, roentgenogram showing the large calculus in the bladder. The pelvic bones and vertebrae show changes due to osteitis deformans. *B*, roentgenogram showing typical changes of osteitis deformans in the skull.

Nachlas, however, was unable to find hypercalcemia in 19 cases of osteo-arthritis or in 18 cases of rheumatoid arthritis. Hench and Rentschler failed to find hypercalcemia in 25 cases of infectious arthritis at the Mayo clinic. Koenig and Bulger likewise were unable to demonstrate hypercalcemia in 30 arthritic patients. Pemberton and his

associates studied the calcium metabolism in arthritic conditions of long duration with limitation of motion and with ankylosis, the type of case in which Mark and also Weill and Guillaumin found high serum values. Their studies gave figures for serum and plasma calcium within the limits usually ascribed to normal blood.

SPONDYLITIS DEFORMANS

This disease is a form of arthritis deformans occurring more often in males than in females. The spinal involvement may be present alone or associated with involvement of peripheral joints. Spondylitis deformans may be the result of repeated acute attacks or of a chronically progressive process and is characterized by bony proliferation causing rigidity of the spinal column.

Grossman stated that among the last 1,000 cases of lithiasis observed in the urologic section of the Hedwig Hospital in the past fifteen years there were 14 cases in which lithiasis was concurrent with diseases of the bone. Among these 14 cases were 6 of arthritis deformans of the spinal column and 2 of spondylitis deformans of the Bechterew type. Eisenstaedt reported that the largest stone he has removed from the bladder was in a patient suffering with severe spondylitis deformans. Schwarz stated that he recently observed a case of traumatic spondylitis deformans (Bechterew's disease) with bilateral nephrolithiasis. Barr and Charles reported the development of multiple calculi in a man 71 years old who had a deformity of the spine resulting from an old destructive lesion of the fourth lumbar intervertebral disk and hypertrophic osteo-arthritis.

Israël recently reported a case of bilateral renal lithiasis in a man 38 years old who suffered with ankylosing spondylarthritis of the Strümpell-Marie type. Roentgen studies showed extensive formation of calculi in both kidneys. Israël discussed the possible factors responsible for the simultaneous occurrence of the two disease processes—the ankylosing spondylarthritis and the bilateral nephrolithiasis—and maintained that the stone formation was dependent on the disease of the spinal column; i. e., he did not believe that both diseases could be attributed to common causes or conditions. In his opinion the factor that influenced the production of renal calculi in the disease of the spine was a disturbance of calcium metabolism as manifested by the increased calcium content of the blood and the increased amount of calcium in the urine. Although such a disorder of metabolism is more common in bone destruction, it may occur in any process of pathologic bone formation, in which category this disease belongs.

NEPHROGENOUS SCOLIOSIS

In 1926 Carty emphasized the diagnostic significance of lateral curvature of the spine caused by muscular spasm. He pointed out that a lumbar scoliosis should direct attention to a renal stone, hydronephrosis or perinephritic abscess, possibly not suspected. He found this deformity in 60 per cent of 100 patients with large renal calculi and stressed the fact that the presence of a lateral deformity may be of considerable importance since this type of calculus may give rise to little or no pain or other symptoms.

In a recent article Blumensaat and Nestman also called attention to the fact that in most cases of renal disease there is an accompanying scoliosis of the lumbar segment of the spinal column. They suggested the use of the term "nephrogenous scoliosis" in preference to the older term "nephritic scoliosis." They found that in cases of renal calculus the curve is convex to the stone; in hydronephrosis, pyonephrosis, pyelitis, tuberculosis, paranephritis and mobile kidney it is concave to the lesion; in cases of tumor the direction of the scoliosis is variable. They maintained that in cases of stone the scoliosis is the result of a protective action whereas in cases of hydronephrosis it is a mechanical response, and in the remaining cases it is caused by the contraction of the muscles on the diseased side.

In 1931 Nuvoli and Impiombato reported 150 cases of malformation of the spine accompanied by the syndrome of urinary calculosis. They examined 150 cases with this syndrome and found calculi in only 26 cases. In all except 16 of the 150 cases there was some malformation of the spine, i. e., lumbarization of the twelfth dorsal vertebra, dorsalization of the first lumbar vertebra, sacralization of the fifth lumbar vertebra, lumbarization of the first sacral vertebra and spina bifida. Milliken reported a case of nephrolithiasis associated with marked scoliosis in a man 25 years old.

CASE 13.—S. W., a white man 34 years old, a salesman, was admitted to Sinai Hospital on July 26, 1924 with the complaint of pain in the right lower quadrant of the abdomen and right side of the back. The family history was unimportant. The patient had a gonorrheal infection at the age of 20 and subsequently an infection in his prostate for which he was treated. The patient stated that in 1919 he had severe colicky pain in his right side, and that an appendectomy was performed but that a normal appendix was found. Five days after the operation he had a similar attack of pain.

Present Illness.—A sudden sharp pain developed in the lower right quadrant of the abdomen radiating to the right testicle two weeks prior to examination. The pain lasted several hours but was not accompanied by nausea, vomiting, chills or fever, nor did it require morphine for relief. There were no symptoms of frequency, urgency, tenesmus, hematuria, etc.

Physical Examination.—The results were essentially negative except for tenderness in the right lower quadrant over the course of the right ureter. There

was marked scoliosis of the dorsal spine with elevation of the right shoulder and general spasticity of all the spinal muscles.

Laboratory Studies.—A voided specimen of urine was negative for albumin and sugar, but on microscopic examination showed a few pus and red blood cells.

Course.—On July 26 cystoscopic and pyelographic study revealed a small calculus in the upper third of the right ureter. Five days later the patient passed a small stone.

The patient failed to return for observation and treatment until July 9, 1928, when he presented himself complaining of pain in the right renal region. Eight weeks previously he had an attack of right renal colic accompanied and followed by diurnal frequency and nocturia but not by hematuria, dysuria or burning. A roentgenogram of the genito-urinary tract taken at this time showed a shadow in the region of the right kidney. The patient was not seen again until Oct. 9,

Fig. 8 (case 13).—Plain roentgenogram showing marked scoliosis with deviation away from the affected side. The shadow seen above the catheter in the eleventh right intercostal space is a calculus in the right kidney.

1929, when he was admitted to the hospital for further study. Cystoscopic and pyelographic studies revealed a calculus in the right renal pelvis (fig. 8). On October 18 a right pyelolithotomy was performed under gas anesthesia, and the calculus was removed. The calculus measured approximately 1.5 by 1 by 0.5 cm. and was reddish yellow and firm with an irregular, warty surface. He made an uneventful recovery. When last seen on July 9, 1931 he was in excellent health.

Diagnosis.—The diagnosis was (1) calculus in the right kidney and (2) scoliosis.

CASE 14.—L. L., a white woman 66 years old, Jewish, a widow and housewife, was referred by, and her case reported through, the courtesy of Dr. S. Lubash of New York. On May 6, 1934, while in New York, the patient was seized with sharp pain in the left upper quadrant of the abdomen. Dr. Lubash performed a cystoscopic and pyelographic study and found a large nonfunctioning calculous pyonephrotic kidney on the left side. The condition of the patient was poor and

an emergency nephrostomy was performed, at which time a large calculus and about a pint (about 473 cc.) of thick pus were removed. The patient made an excellent recovery, and at the time of discharge from the hospital roentgen studies revealed no evidence of urinary calculi. She returned to her home in Baltimore with the wound well healed and a properly functioning nephrostomy tube in place. Further cystoscopic studies revealed a marked restoration of function in the left kidney with a decided reduction in the size of its pelvis. The nephrostomy tube was removed on Sept. 27, 1934, and the wound closed promptly. A secondary nephrectomy does not appear to be necessary at this time.

The patient stated that she had had dull pains in the lumbar portion of the spine for ten years and had received treatment for hypertrophic arthritis and

Fig. 9 (case 14).—Roentgenograms showing marked scoliosis of the lumbar portion of the spine with deviation of the spine toward the left side. The left ureter is filled with dye up to the tip of the catheter, at which point a large calculus can be seen.

scoliosis of the lumbar part of the spine. A roentgenogram revealed marked scoliosis of the lumbar part of the spine with deviation to the left (fig. 9).

Diagnosis.—The diagnosis was (1) left calculous pyonephrosis and (2) scoliosis.

HYPERPARATHYROIDISM

Barr, Bulger and Dixon emphasized the relationship of parathyroid hyperplasia (adenoma) to the bone changes in osteitis fibrosa and called the clinical syndrome "hyperparathyroidism." They pointed out that

the symptoms of clinical hyperparathyroidism are similar to those produced by experimental injection of excessive amounts of parathyroid extract. They also stressed the following important clinical features: (1) hypercalcemia, (2) abnormal excretion of calcium in the urine, (3) hypertonia and muscular weakness, (4) decalcification and rarefaction of bones and (5) multiple cysts or tumors of the bones. The following features may also occur: hypophosphatemia, a negative calcium balance and nephrolithiasis.

In 1931 Hunter collected 32 cases of hyperparathyroidism and found renal calculi in 10 cases. In 1934 Barney and Mintz reviewed the literature and brought the total to 65 cases reported by 36 different authors. They found renal calculi in 15 cases (23.07 per cent); in 10 cases the calculi were bilateral. In addition, they reported the presence of renal calculi in 11 of 18 cases of hyperparathyroidism observed in a series at the Massachusetts General Hospital in which the diagnoses were confirmed by operation, as indicated in the report of Churchill and Cope. These 11 cases are included in a series of 104 cases of urinary calculi which Barney and Mintz have encountered since 1933 and studied particularly from the standpoint of changes in the blood calcium and phosphorus. They stated that parathyroid disease is the apparent etiologic factor in 10 per cent of the cases of urinary lithiasis.

RENAL RICKETS AND CHRONIC INTERSTITIAL NEPHRITIS IN CHILDHOOD

Chronic renal disease in infancy and childhood and the closely allied disease renal rickets have received considerable attention in British medical literature; only recently have they been discussed in French, German, Italian and American literature. The first to note the association of chronic renal disease with changes in the bones was Lucas, who in 1883 described late rickets and albuminuria in 5 patients.

The term "renal dwarfism" or "renal nanism" is employed to denote the small stature and stunted growth that may accompany chronic interstitial nephritis in early life. The term "renal infantilism" is applied to a chronic kidney disease in which faulty or complete lack of primary and secondary sexual development is a special feature. Mitchell in 1930 presented an excellent review of chronic interstitial nephritis in childhood and renal rickets, and we have drawn much of our information from his work on this subject. He was able to collect about 200 authentic cases of chronic interstitial nephritis in persons under 20 years of age. In 78 of these cases there were clinical or roentgenologic evidences of abnormal changes in the bones, to which he added 2 cases of his own, making a total of 80 cases of renal rickets. It is the latter group which particularly commands our attention in this paper.

The term "renal rickets" or "renal pseudo-rickets" is employed to designate the chronic interstitial nephritis in infancy and childhood which is accompanied by marked alteration in the growth of the bones and by various types of bony deformities. The amount of bone change and deformity is closely associated with the time of onset, duration and severity of the chronic disease of the kidney.

In renal rickets there is a disturbed relation between the calcium and the phosphorus of the blood. In the stage of active symptoms the calcium content of the blood is frequently below the normal level of from 10 to 12 mg. per hundred cubic centimeters and the inorganic phosphorus above the normal level of from 4.5 to 5.5 mg. The lowered blood calcium and the increased blood phosphorus serve to distinguish renal rickets from hyperparathyroidism, in which the reverse is true.

While the usual pathologic process in the kidneys in renal rickets is a chronic interstitial nephritis there are many cases in which the renal insufficiency is due to some other pathologic condition in the urinary tract. Mitchell stressed the fact that a functional insufficiency and symptoms similar to those produced by chronic interstitial nephritis may be caused by such lesions as congenital or acquired obstruction of the urinary tract, chronic infections, renal calculi and congenital renal anomalies.

Several authors (Goodhart, Barber and Parsons) have commented on the occurrence of renal calculi in renal rickets but have not given detailed reports of any cases seen by them. Davies-Colley reported a case of renal rickets in a 13 year old girl who had four impacted stones in the right ureter and a number of angular stones in the right kidney, which was the seat of multiple suppurative lesions. Zanoli reported a case in which a calculus in the bladder was demonstrated by roentgenogram. Mitchell stated that in a case which he observed there was a heavy amorphous deposit of salts in the tubules and pelvis of each kidney. Tuechter reported a case of renal calculus in a youth of 18 years, diagnosed as renal infantilism associated with hypothyroidism.

CONCLUSIONS

A review of the literature and a study of 14 personal cases of urinary calculi in association with various bone diseases warrant the following conclusions:

1. There appears to be a definite etiologic relationship between urinary lithiasis and various chronic bone diseases; consequently, in all cases of urinary calculi information concerning a previous bone injury or disease should be sought and carefully considered from an etiologic standpoint.

2. The development of urinary calculi during the course of chronic bone disease is uncommon though not infrequent.

3. Infection of the urinary tract secondary to acute or chronic infection of the bones or joints, i. e., arthritis or osteomyelitis, may be a predisposing factor in the formation of urinary calculi.

4. Urinary calculi may develop following injuries of the vertebrae and cord.

5. The formation of urinary calculi in the presence of rickets, osteitis deformans, osteomalacia, osteitis fibrosa of von Recklinghausen, osteitis fibrosa cystica associated with hyperparathyroidism and other diseases of bone appears to be dependent on a disturbance of the calcium-phosphorus metabolism which upsets the colloid-crystalloid equilibrium of the urine with subsequent precipitation and coalescence of the urinary constituents.

6. Careful attention should be paid to providing an adequate diet in the treatment and prevention of urinary calculi in all persons, especially those afflicted with chronic bone diseases, since a diet deficient in vitamin A and inorganic calcium and phosphorus is an etiologic factor in the formation of urinary calculi in the experimental animal and is reputed to be an etiologic factor in the clinical and experimental production of several types of chronic bone diseases, i. e., rickets, osteitis deformans and osteomalacia.

7. We report 14 cases of urinary calculi in association with bone diseases, viz.: 4 cases following amputation of the extremities; 2 following osteomyelitis; 3 following fracture of long bones; 1 following fracture of the pelvis; 1 following tuberculosis of the hip joints; 1 following arthritis deformans with associated osteitis deformans, and 2 associated with scoliosis.

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CHRONIC NONSPECIFIC THYROIDITIS

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Report of Cases of the Fibrous Type
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INTRODUCTION

Chronic nonspecific thyroiditis is a nonsuppurative disease of unknown etiology, affecting the thyroid gland of men and women, both young and old. It is characterized by the rapid development of an extremely hard, frequently fixed tumor, without previous or present signs of hypothyroidism or hyperthyroidism, although a goiter may have been present for some time. There is little, if any, associated fever or leukocytosis. Pain is very infrequent, dyspnea, dysphagia and aphonia being the most common symptoms. The regional lymph nodes are rarely enlarged. Metastases never occur.

There are two pathologic types. One is characterized chiefly by fibrosis, and the other, chiefly by lymphocytic infiltration. These types do not include the somewhat similar-appearing pathologic changes of tuberculosis, syphilis, adenomas with fibrosis, atrophy and fibrosis of myxedema and the lymphocytic infiltration of hyperthyroidism.

It is the commonly accepted opinion that the lymphoid form represents the early, and the fibrous form the late, stage of the same disease. A study of twelve cases and a review of reported cases to date suggest that these types are probably separate and distinct entities.

Submitted in partial fulfilment of the requirements for the degree of Doctor of Medical Sciences.

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The cases which I shall record in detail were observed during eighteen hundred thyroidectomies performed at the Presbyterian Hospital. They were selected from a somewhat larger group after careful review of the clinical as well as the pathologic features. This group included cases in which the condition was thought to be "chronic thyroiditis," "tuberculosis of the thyroid (?)" and "syphilis (?)" and cases of unusual fibrosis and lymphoid hyperplasia not associated with adenoma, hypothyroidism or hyperthyroidism.

HISTORICAL SUMMARY

Riedel in 1883 observed a rare and peculiar condition of the thyroid gland which he described as "chronic inflammation of the gland leading to the formation of an iron-hard tumor." It was not until twelve years later that he had the opportunity to observe a second case and in the following year a third one. In 1896 and 1897, he published his observations of the disease to which he gave the name *eisenharte Strumitis.*

However, it is worthy of mention that Bowlby also observed a similar case in 1885 and reported his observations in the following year, twelve years before Riedel, under the title "Infiltrating Fibroma (? sarcoma) of the Thyroid Gland."

The condition has been subsequently described by various writers under names more or less descriptive of some of the clinical or pathologic features, namely, *inflammation chronique primative, cancériforme,* Tailhefer, 1898; *dégénéresence fibreuse du corps thyroide,* Ricard, 1901; primary chronic inflammation, Berry, 1901; *eisenharter Strumitis,* Silatschek, 1910; *Riedelsche Struma,* Spannus, 1910; *thyroidite ligneuse,* Delore and Alamartine, 1911; thyroiditis chronica maligna, Meyer, 1913; *chronische Thyroiditis,* Heineke, 1914; woody thyroiditis, Nicholoson, 1921; chronic thyroiditis (primary), Thomas and Webb, 1923; chronic productive thyroiditis, St. George, 1924; nonsuppurative chronic thyroiditis, Hahn, 1925; benign granuloma of the thyroid, Heyd, 1929; thyroiditis simplex, Bruce, 1931.

In 1912 Hashimoto reported four cases of "chronic inflammation of the thyroid," all of which occurred in women. To this disease he gave the name struma lymphomatosa. These cases differed from those previously described in that the enlargement of the thyroid gland was due primarily to a dense infiltration of lymphoid tissue rather than being chiefly composed of fibrous tisssue. He concluded this was not the same disease that had been described by Riedel and excluded his cases from those of lymphosarcoma, tuberculosis, syphilis and hyperthyroidism.

Ewing applied the name benign granuloma to this type, which he believed to be the early stage of the previously described disease. Subsequent writers, with few exceptions (Reist [1912], Heineke [1914], Perman and Wahlgren [1927] and Graham and McCullagh [1931]),

have accepted this opinion and have recorded cases similar to those described by Hashimoto as instances of an early stage of Riedel's strumitis.

REPORT OF CASES OF THE FIBROUS TYPE

CASE 1 (Reported by St. George).—*History.*—A Russian man, aged 25, was admitted to the hospital on Dec. 9, 1919, with the complaints of swelling of the neck, dyspnea and dysphagia of three months' duration. The family, past and personal histories were essentially unimportant. The patient had always enjoyed good health, and there was no history of previous symptoms referable to the thyroid gland. Three months before admission he first noticed a swelling on the right side of the neck, and during this period dyspnea and dysphagia developed.

Examination.—The temperature was 98.6 F.; the pulse rate, 98, and the respiratory rate, 20. The results of the physical examination were negative, except for obvious dyspnea and the presence of a mass the size of a hen's egg, corresponding in position to the right lobe of the thyroid gland. The Wassermann reaction, the blood count and the basal metabolic rate were not recorded.

A diagnosis of sarcoma of the thyroid gland was made.

Operation (Dr. George E. Brewer; December 10).—The right lobe of the thyroid gland was involved in a new growth which extended out into the surrounding tissue, causing a great increase in the density of the capsule. The recurrent laryngeal nerve was enclosed, and the gland was adherent to the trachea and the esophagus. The lower pole was well below the clavicle. The mass was very hard and but slightly movable. The overlying muscles were densely adherent, which made the exposure difficult. It was necessary to resect a portion of the clavicle to deliver the lower pole. In one area a portion of the mass invaded the wall of the trachea and could not be removed. All the remaining tumor was excised, and 120 mg. of radium was placed in the region of the portion which was left. The radium was removed two hours later.

Pathologic Report.—The specimen measured 3 by 4.5 by 4.5 cm. The surface was irregular and partially covered by a capsule. The tissue was stony hard. On section, there was a central portion 1.5 cm. in diameter with a similar area in one pole, which had the appearance of thyroid parenchyma containing colloid. The remaining major portion of the specimen was composed of dense, hard, white fibrous tissue.

Microscopically, the sections were almost entirely composed of dense, hyalinized, fibrous connective tissue throughout which were numerous plasma cells and scattered lymphocytes. A few scattered degenerating acini were interspersed through the sections. The zone between the fibrous area and the recognizable thyroid parenchyma was formed of dense collections of lymphocytes, in which there was only an occasional germinal center. The remaining acini contained colloid and were lined by low cuboidal epithelium. There was a marked increase in the intervening connective tissue stroma, and here also small collections of lymphocytes and scattered lymphocytes were present. No polymorphonuclear leukocytes or giant cells were noted. The acini at the inner edge of the fibrous zone showed varying degrees of degeneration. The vessels showed no evidence of pathologic change.

Postoperative Course.—The convalescence was uneventful except for a slight increase in dyspnea on the sixth day. Radium was applied externally on the eleventh day for four hours. The patient was discharged on the twenty-fourth

day free from symptoms. He was alive and well, free from symptoms and without evidence of recurrence thirteen and one-half years after operation.

CASE 2.—*History.*—A Japanese housewife, aged 47, was admitted to the hospital on July 19, 1928, with the complaint of swelling of the neck of one month's duration. The family history was not obtainable. The patient had always been healthy. Her husband died from an unknown cause. There were two children alive and well, and two had died in infancy. There was no history of a previous disorder of the thyroid gland. Her weight had been constant, about 135 pounds (61.2 Kg.), until four months before admission, during which time she lost 20 pounds (9.1 Kg.). She had pleurisy with effusion at the age of 18, following which she was incapacitated for about one year. Two years before admission she began to tire easily, noticed a fine tremor of the hands and experienced dyspnea on exertion. One month before admission she noticed a swelling on the left side of her neck, which increased in size. She was conscious of the mass on swallowing and experienced a throbbing sensation on the left side of the head.

Examination.—The temperature was 99.2 F.; the pulse rate, 100, and the respiratory rate, 20. The blood pressure was 128 systolic and 80 diastolic. The weight was 116 pounds (52.6 Kg.). The patient was well developed and well nourished. There was no exophthalmos or ocular signs associated with exophthalmic goiter. There was an asymmetrical enlargement of the thyroid gland, the left side being much larger than the right. The gland was nodular, firm and slightly tender. There was no tremor of the fingers. The basal metabolic rate was 4. Urinalysis gave negative results. The Wassermann reaction was negative. The blood count was not recorded. Because of the loss of weight, the rapid growth of the mass and the extreme hardness, the possibility of carcinoma was suspected.

A diagnosis of carcinoma of the thyroid gland was made.

Operation (Dr. Frank Meleney; July 23, 1928).—All the left lobe and the isthmus were involved in a hard nodular process. There seemed to be slight infiltration of the capsule at the lower pole. On the right, however, only a small portion of the gland near the isthmus seemed to be involved. Almost the entire left lobe and the isthmus were removed.

Pathologic Report.—The gross specimen consisted of three pieces of tissue, which measured 4 by 2.5 by 1 cm., 4 by 3 by 1.5 cm. and 3 by 1 by 1 cm., respectively. All were similar in appearance. They were very firm in consistency. The cut surface had a homogeneous dense, grayish, fibrous appearance, throughout which were scattered areas of light brown. In only a small portion of one piece could colloid be recognized. In this there appeared to be marked fibrous trabeculae extending through the colloid. No cysts or adenomas were present. The capsule was thin.

Microscopic examination showed little recognizable thyroid tissue. The sections were almost entirely composed of coarse bands and interlacing strands of dense fibrous connective tissue, for the most part hyalinized. Scattered lymphocytes and plasma cells were present, but no lymph follicles were noted. The remaining acini formed scattered groups. Some were lined by flattened epithelium and contained colloid. Others showed varying degrees of degeneration and absence of colloid. There were many giant cells in this area. These multinuclear cells had an appearance strongly suggestive of fusion of epithelial cells from the acini around droplets of colloid. No areas of necrosis, caseation or calcification were noted. An extensive search for tubercle bacilli was made in sections stained by the Ziehl-Neelsen method, but none were found.

Postoperative Course.—The patient regained the lost weight within two months. She was well three years after operation, was able to do all her housework and was free from symptoms.

CASE 3.—*History.*—A Mexican housewife, aged 35, was admitted to the hospital on July 31, 1929, with complaints of weakness and loss of weight of six months' duration and of swelling of the neck of eight months' duration. The family history was unimportant. The patient had always lived in Mexico and had come to New York one week before admission. There were no previous serious illnesses. She was married and had eight children, all of whom were

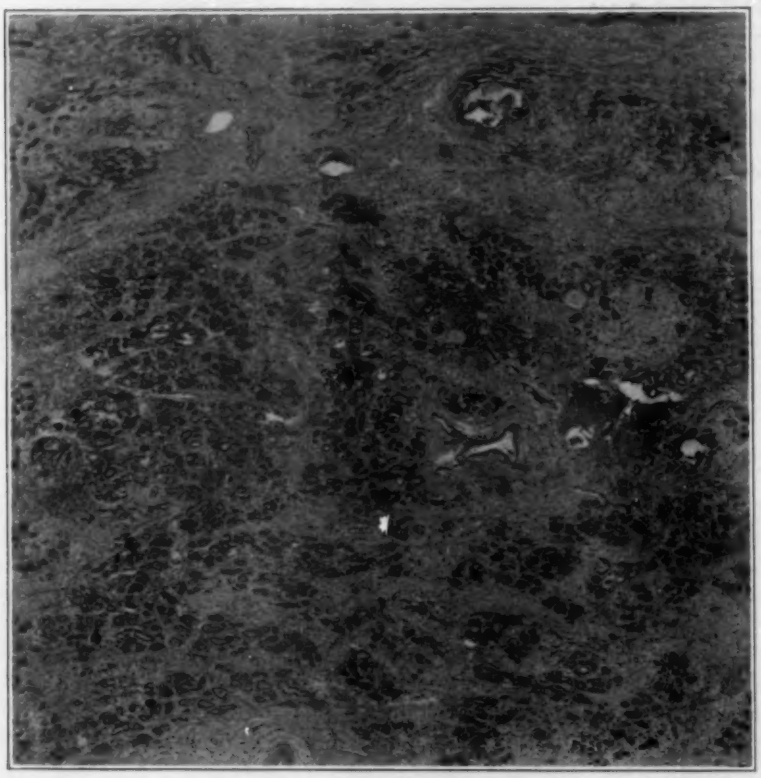

Fig. 1 (case 3).—A section of the thyroid gland in a case of thyroiditis (fibrous type) showing fibrous tissue throughout this peripheral portion of the gland. The acini are all small, atrophic and widely separated. There are few inflammatory cells. Magnification, × 150.

living. Eight months before admission she first noticed a swelling in the region of the thyroid gland. This was tender at first but not at the time of admission. She lost 25 pounds (11.3 Kg.) of weight during this time and experienced dyspnea on exertion and attacks of dizziness. She also noticed a fine tremor of the hands.

Examination.—The temperature was 99 F.; the pulse rate, 100, and the respiratory rate, 22. The blood pressure was 160 systolic and 83 diastolic. The weight was 123 pounds (55.8 Kg.). The patient was well developed and well nourished. There was no exophthalmos. The left lobe of the thyroid gland was larger than

the right, and both were very firm. The left lobe was slightly tender. The red blood cells numbered 4,240,000, with 92 per cent hemoglobin; the white blood cells numbered 8,700, with 67 per cent polymorphonuclears, 25 per cent lymphocytes and 8 per cent eosinophils. The Wassermann reaction was negative. The basal metabolic rate was +16. The urine contained an occasional hyaline cast. The patient was given compound solution of iodine for eight days prior to operation.

A diagnosis of adenoma of the thyroid gland was made.

Operation (Dr. W. B. Parsons; August 13).—The gland was small, firm and sclerotic. The overlying muscles were adherent to the upper pole. The capsule

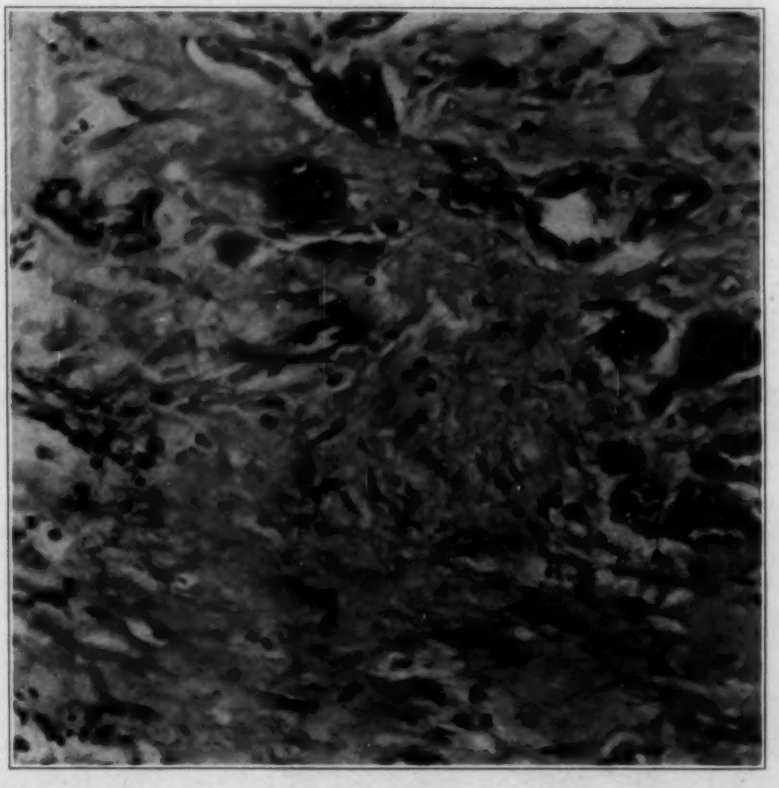

Fig. 2 (case 3).—A high magnification of the section shown in figure 1. Atrophic thyroid acini are seen scattered through the dense fibrous tissue. Magnification, × 500.

was very thick. The gland appeared to be made up of fibrous tissue in which there were a few small areas of thyroid parenchyma. The left lobe was somewhat larger than the right. A subtotal resection was done on both sides.

Pathologic Report.—The gross specimen consisted of portions of both lobes of the thyroid gland. These measured 4 by 2 by 1 cm. and 3 by 1.5 by 0.4 cm., respectively. The appearance was similar. The outer surface was rough. The cut surface showed numerous fibrous septums running throughout, with intervening pink areas.

Microscopically, there was a marked increase in the interlobular and intralobular stroma formed of dense connective tissue showing a mild degree of hyalinization. The acini were small and formed groups which were widely separated by dense connective tissue (fig. 1). They were lined by cuboidal epithelium, and very few contained colloid. Many appeared compressed and seemed to be undergoing degeneration (fig. 2). An occasional giant cell was present. A small collection of lymphocytes and many scattered lymphocytes were present in the stroma. There were no germinal centers. There were no polymorphonuclear leukocytes, but many plasma cells were present. The vessels were not thickened. No tubercles, areas of caseation or adenomas were noted.

Postoperative Course.—The patient was discharged on the fourteenth day. She returned to Mexico and still suffered from several of her preoperative symptoms, especially fatigue, with the addition of palpitation. Six months after operation she noticed a swelling on the right side of the neck in the region of the thyroid gland. There was, however, no dyspnea, dysphagia or cough. The swelling was slightly painful. The patient had lost 16 pounds (7.3 Kg.) in weight. The basal metabolic rate was +8. The blood pressure was 200 systolic and 120 diastolic. It seems certain from recent examination of the patient, two years after operation, that many of the initial symptoms were due not to hyperthyroidism but rather to hypertension and chronic nephritis, which was confirmed by laboratory examinations.

Case 4.—*History.*—A Negress, aged 42, was admitted to the hospital on Dec. 23, 1929, with the complaint of a lump in the neck of three months' duration. The family history was unimportant. There had been no serious illnesses, and there was no history of recent infections, of previous symptoms referable to the thyroid gland or of venereal disease. Three months before admission the patient noticed a slight swelling of the neck. This increased slowly at first but enlarged rapidly in the three weeks before admission. The mass was not tender. There was slight hoarseness, which the patient attributed to a cold, but no dyspnea, dysphagia, palpitation, nervousness or loss of weight.

Examination.—The temperature was 99 F.; the pulse rate, 90, and the respiratory rate, 20. The blood pressure was 124 systolic and 90 diastolic, and the weight was 147 pounds (66.7 Kg.). The patient was well developed and well nourished. No tremor or exophthalmos was present. There was a moderate-sized, firm, nontender movable mass in the left lobe of the thyroid gland. The right lobe was smaller and irregular. The regional lymph nodes were not enlarged. The Wassermann reaction was 4 plus. The basal metabolic rate was ±0. The urine was normal. A roentgenogram showed a possible substernal prolongation of the mass, with a slight deviation of the trachea to the right. Because the mass did not feel like an adenoma and was slightly more fixed than usual, syphilis of the thyroid gland was considered as a possible diagnosis. Three intravenous injections of neoarsphenamine were given at weekly intervals. As there was no change in the mass, operation was decided on.

A diagnosis of adenoma of the thyroid gland and syphilis of the thyroid gland (?) was made.

Operation (Dr. L. Sloan; December 26).—The thyroid gland on the left side was very hard, and practically the entire lobe seemed to be involved in a sclerosing process, which involved not only the gland itself but also the structures adjacent to it. The under-surfaces of the pretracheal muscles and the tissue over the greater vessels were adherent to the thyroid gland, and were formed of tissue which resembled the wall of a long-standing abscess, but not a gumma. It was

possible only with great difficulty to separate the thyroid gland from the adjacent structures because of adhesions and the resistance of the tissue. Toward the left upper pole and midline at the lower pole the resistant tissue seemed to merge into normal-appearing gland. On the right side there were two or three small nodules, but the process seemed to be different from the left side. There was a pyramidal lobe which appeared to be free from pathologic change. Both lobes extended behind the sternum. The trachea was considerably displaced to the right. The entire left lobe, the pyramidal lobe and a portion of the right lobe were removed.

Pathologic Report.—The gross specimen consisted of portions of both lobes of the thyroid gland. These measured 7 by 6 by 4.5 cm. and 6 by 3 by 2.5 cm. The larger was somewhat cylindric, and one surface was almost entirely covered by a thin fibrous capsule. The specimen felt quite firm. On section, the surface presented a dense, thick, white peripheral portion almost entirely surrounding a zone of what appeared to be thyroid tissue. A small layer of thyroid tissue formed the outer edge. The central portion was somewhat cystic and contained areas of hemorrhage. Small areas of relatively normal-appearing thyroid tissue were present in the fibrous layers. The smaller specimen had a slightly nodular surface and was almost entirely covered by a thin fibrous capsule. It was firm throughout, but not as hard as the larger specimen. The cut surface was composed of several small areas of thyroid parenchyma separated by dense fibrous tissue. There were a few small cystlike spaces filled with colloid, but no evidence of calcification.

Microscopic section of the dense white zone showed it to be composed of hyalinized connective tissue throughout which were many plasma cells, lymphocytes and an occasional giant cell. A few degenerating acini and an occasional intact one containing colloid were present in this area. Small collections of lymphocytes occupied the intervening area between the fibrous zone and the thyroid parenchyma. These did not contain germinal centers. The acini occupying the central portion varied in size and shape. They were lined by flattened cuboidal epithelium and were well filled with colloid. Bands of coarse fibrous tissue traversed this area between groups of acini, and those at the edge showed degeneration. A few giant cells were present. These appeared to be formed by fusion of epithelial cells around colloid. There were no tubercles present. The section of the smaller lobe was similarly composed of dense hyalinized connective tissue, infiltrated with plasma cells and lymphocytes. An occasional germinal center was present. There were small groups of compressed acini scattered through the sections. These were lined with flattened epithelium and contained colloid. There were no tubercles or areas of necrosis. No tubercle bacilli were found in sections stained by the Ziehl-Neelsen method. There was nothing in the sections on which a diagnosis of syphilis could be based. The vessels were not thickened, and there was no perivascular small round cell infiltration.

Postoperative Course.—The postoperative convalescence was uneventful aside from a slight superficial infection of the wound. The patient was discharged on the sixteenth day and felt quite well in one month, during which there was a gain in weight and strength. There was no dyspnea, dysphagia or evidence of recurrence. The treatment for syphilis was continued. All the induration in the neck disappeared in six months. Thirteen months after operation the patient felt very well and was working without fatigue or disability. The basal metabolic rate was +3. Nineteen months after operation the patient weighed 151 pounds (68.5 Kg.). The basal metabolic rate at this time was +3. Two years after

operation she weighed 157 pounds (71.2 Kg.). There was no evidence of hyperthyroidism or hypothyroidism and no evidence of recurrence. The Wassermann reaction was negative.

CASE 5.—*History.*—A woman, aged 60, was admitted to the hospital on Aug. 14, 1931, with the complaint of a swelling of the neck of two months' duration. The family history was irrelevant. The patient was born in Poland but had lived in the United States for twenty-seven years. She had been married thirty-five years and had five children, all of whom were alive and well. There was no history of a previous disorder of the thyroid gland or of serious illnesses. Three months before admission the patient thought that she had caught a cold, and she awoke one morning with stiffness of the neck. About one month later she noticed a swelling of the neck. This did not increase in size up to the time of admission. There was no pain, but slight tenderness on pressure was experienced. There was no nervousness, palpitation, tremor, exophthalmos, dyspnea, dysphagia or aphonia.

Examination.—The temperature was 99.8 F.; the pulse rate, 74, and the respiratory rate, 20. The blood pressure was 160 systolic and 104 diastolic, and the weight was 125 pounds (56.7 Kg.). The patient was well developed and well nourished. There was a marked enlargement of the thyroid gland in the anterior aspect of the neck. This was extremely hard. It moved on swallowing and was not attached to the skin. The mass was slightly tender on pressure. The surface was smooth. There were several small firm nodes in both submaxillary regions. There was no exophthalmos or tremor. The lungs were clear. A roentgenogram of the neck showed calcification of the left side, with some deviation of the trachea to the right. Because of the extreme hardness of the gland, carcinoma with metatases was suspected. One node, removed for biopsy, proved on microscopic examination to be tuberculous. The Wassermann reaction was negative. The basal metabolic rate and the blood count were not recorded.

A diagnosis of carcinoma and tuberculosis (?) of the thyroid gland was made.

Operation (Dr. L. Sloan; August 31).—The gland was extremely hard and considerably enlarged, but there was no evidence of invasion of the surrounding tissue. It was not adherent to the muscles and stripped away from the trachea with ease. The appearance was homogeneous throughout and was that of an encapsulated gland with very dense and fibrous parenchyma, which in some areas resembled normal thyroid. The left lobe was twice the size of the right. Almost a perfect mold of the trachea was formed on the posterior surface. The major portions of both lobes with the entire isthmus were removed. There was little bleeding.

Pathologic Report.—The specimen consisted of the major portions of both lobes of the thyroid gland and the isthmus. Both lobes were almost entirely covered by a thin smooth capsule. The right portion measured 7 by 4.5 by 2.5 cm. The surface was finely irregular but not nodular. The left measured 9 by 6.5 by 4.5 cm. This was grossly lobulated. Both were similar on section. They were extremely dense and cut with increased resistance. The appearance was that of homogeneous dense white fibrous tissue, with little evidence of colloid. There were no adenomas or areas of calcification.

Microscopically, sections from different portions of both specimens were similar. They showed many coarse bands of hyalinized connective tissue arranged in a very irregular manner. The intervening spaces were formed of interlacing strands of dense connective tissue, which was also for the most part hyalinized. The

intervening spaces between the strands of connective tissue contained numerous plasma cells and lymphocytes. Little parenchyma remained. Very few acini exhibiting various degrees of degeneration were scattered through the sections. An occasional one contained colloid. These showed no evidence of epithelial hyperplasia. A few multinucleated giant cells were present which had the appearance of being formed by fusion of epithelial cells around droplets of colloid. No pathologic changes were noted in the vessels. The lymphocytes for the most part were diffusely scattered, with the exception of a few small collections, only one of which contained a germinal center. There were no tubercles present.

Postoperative Course.—The patient was discharged on the fourteenth day. She was slightly hoarse two months after operation. The basal metabolic rate was 10. Laryngoscopic examination showed paralysis of the left vocal cord. The patient was given thyroid extract, 0.03 Gm., three times a day. One month later she was feeling stronger and doing housework without fatigue. There was still some hoarseness present. The basal metabolic rate was 8. Nine months after operation there was no evidence of myxedema; consequently the administration of thyroid extract was discontinued. The basal metabolic rate was 3. The patient was well and was free from symptoms and evidence of myxedema fifteen months after operation. Six months later her general appearance was good, and the skin was warm and soft and not thick. She had become more obese, but the obesity was not of an abnormal type. She looked less like a person with hypothyroidism than before operation. Thyroid extract, 0.06 Gm. daily, was prescribed. Two years after operation the patient weighed 155 pounds (70.3 Kg.). Her general health was excellent, and no evidence of hypothyroidism was noted. There was no evidence of recurrence.

CASE 6.—*History.*—A Jewess, aged 31, was admitted to the hospital with complaints of swelling of the neck of eighteen months' duration and dysphagia of four months' duration. The family history was unimportant. There was no history of previous serious illnesses or of disorders of the thyroid gland. She had been previously treated with a diet for a gastric ulcer, the presence of which had been confirmed by roentgenographic examination. She was free from symptoms for five years. Eighteen months before admission she noticed a swelling of the neck. There was no fatigue, nervousness, loss of weight, tremor or irritability. The basal metabolic rate on a previous examination was "normal." The swelling increased markedly in the four months prior to admission. The patient experienced a sense of fulness in the neck, with dysphagia but no dyspnea, pain or palpitation.

Examination.—The temperature was 99 F.; the pulse rate, 88, and the respiratory rate, 22. The blood pressure was 143 systolic and 75 diastolic. The weight was 140 pounds (63.5 Kg.). The patient was a well developed and well nourished woman who did not appear to be acutely ill. There was no exophthalmos. There was a diffuse, stony hard swelling of the thyroid gland which was not tender and moved on swallowing. The lateral lobes and the isthmus were clearly defined. The skin was freely movable, and the gland did not feel attached to the deeper structures. The regional lymph nodes were not enlarged. The urine was normal. The blood count and Wassermann reaction were not recorded.

A diagnosis of chronic thyroiditis was made.

Operation (Dr. W. B. Parsons; March 9).—The thyroid gland was hard; the normal gland had been apparently replaced by dense white tissue. There was no apparent invasion of the overlying structures. A frozen section showed what

was thought to be a malignant condition of the thyroid gland, and consequently total thyroidectomy was performed. The parathyroid bodies were carefully preserved.

Pathologic Report.—The specimen consisted of the entire thyroid gland. This was in three pieces, which measured 7 by 4 by 2.5 cm., 6 by 4.5 by 2.3 cm. and 4 by 2.2 by 1.5 cm., respectively. They were irregular in shape, and the surfaces were coarsely nodular. Each was stony hard in consistency and cut with difficulty. They were similar on section, being composed of dense white fibrous

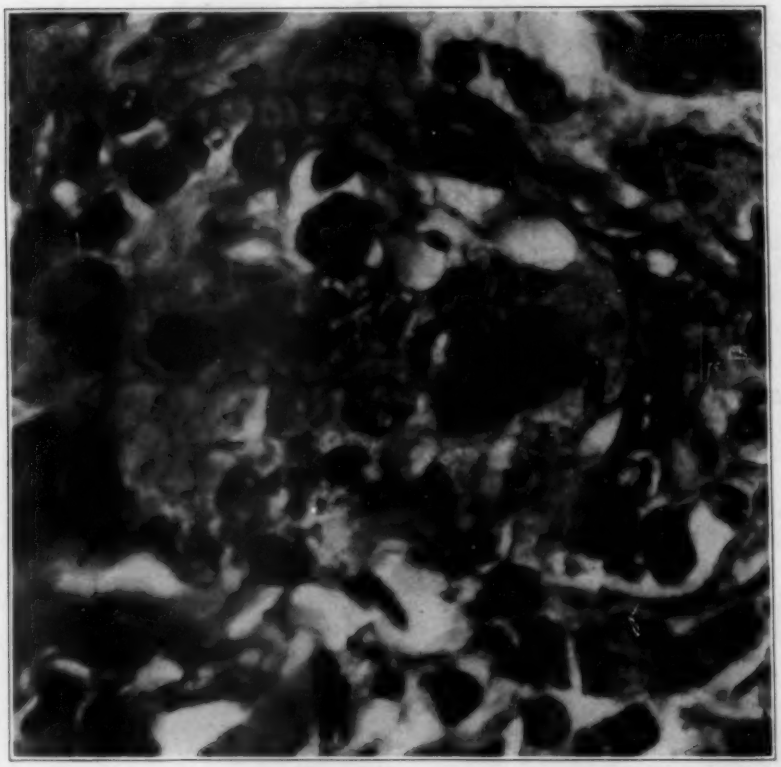

Fig. 3 (case 6).—A high power detail photomicrograph of a section of the thyroid gland in a case of thyroiditis (fibrous type) to show the type of cellular infiltration. The majority of the small cells with eccentric nuclei are plasma cells. The lymphocytes are the small cells with darkly stained, centrally placed nuclei. The larger cells toward the center of the picture with granular cytoplasm are thyroid epithelial cells. They have lost their acinar arrangement. Thick bands of collagen are seen in all parts of the picture. Magnification, × 700.

tissue. There was no recognizable thyroid tissue present. No areas of degeneration or of calcification were observed.

Microscopically, there was a diffuse formation of hyalinized fibrous connective tissue. This was arranged in the form of dense bands with intervening areas of interlacing strands of connective tissue. The acini were separated by connective

tissue and appeared compressed. Few contained colloid, and many showed degeneration. Numerous multinuclear giant cells were present, formed by fusion of epithelial cells of the acini. Some contained droplets of colloid. The epithelium was cuboidal. Many plasma cells and lymphocytes were scattered through the fibrous tissue (fig. 3). A few small collections of lymphocytes were present. These were most marked in the thickened capsule. The vessels showed no unusual change. No tubercles or areas of necrosis were noted. There was no evidence of malignancy.

Postoperative Course.—The basal metabolic rate on the fifth day was —7. The patient was discharged on the tenth day. Two weeks after operation she complained of a peculiar sensation in her hands. A Chvostek sign which had been present a week before could not be elicited. Calcium chloride was prescribed. Five months later the patient weighed 127 pounds (57.6 Kg.). The basal metabolic rate was +14. There was no evidence of deficiency of calcium metabolism or hypothyroidism. Nine months after operation she showed signs of myxedema for the first time. The weight was 132 pounds (59.9 Kg.). The speech was thick, and there was puffiness under the eyes. The basal metabolic rate was 7. Thyroid extract, 0.06 Gm. three times a day, was prescribed.

CASE 7.—*History.*—A Puerto Rican woman, aged 38, was admitted to the hospital on Dec. 4, 1931, with complaints of soreness of the throat and a swelling of the neck of one month's duration and chills, fever and dysphagia of four days' duration. The family history was unimportant. The patient was married and had two children, who were alive and well. There had been no serious infections or previous symptoms referable to the thyroid gland. For one month before admission she had noticed pain on pressure in the region of the thyroid gland and a slight swelling. This slowly increased in size until four days before admission, when the patient experienced difficulty and pain on swallowing. At this time she had a chill in the evening and one each of the following evenings, with a feeling of fever afterward, which she attributed to a cold.

Examination.—The temperature was 99.8 F.; the pulse rate, 84, and the respiratory rate, 20. The blood pressure was 114 systolic and 82 diastolic, and the weight was 131 pounds (59.4 Kg.). The patient was well developed and well nourished and did not appear to be acutely ill. There was no exophthalmos or evidence of hyperthyroidism or hypothyroidism. There was a slight fulness of the left side of the neck in the region of the thyroid gland. A few small slightly tender lymph nodes were present on each side of the neck. There was marked tenderness over the left lobe of the thyroid and the isthmus. This felt firm. The overlying skin was not indurated or adherent, nor was the gland adherent to the surrounding structures. No fluctuation was present. The blood count on admission was 14,500 white blood cells, with 67 per cent polymorphonuclears, 29 per cent lymphocytes, 3 per cent monocytes and 7 per cent eosinophils. Two days later the count was 3,420,000 red blood cells, with 70 per cent hemoglobin and 10,240 white blood cells with 70 per cent polymorphonuclears, 27 per cent lymphocytes, 2 per cent monocytes and 1 per cent eosinophils. The basal metabolic rate was +33. This, however, was not considered a true reading because of fever and poor cooperation of the patient. The Wassermann reaction was negative. Urinalysis and laryngoscopic examination gave negative results. An ice collar was applied to the neck for three days before operation, at which time the temperature varied between 99.2 and 101.8 F.

A diagnosis of chronic thyroiditis was made.

Operation (Dr. L. Sloan; December 8).—The left lobe was very hard and seemed to be made up of fibrous tissue similar to that of the previous glands, which was described as presenting chronic thyroiditis. The left lobe was larger than the right, but even so it was quite small. The gland was adherent to the surrounding structures, but not so much so that it could not be stripped away. It was closely adherent to the trachea. The capsule appeared thickened. The right lobe was softer than the left, but there was not a sharp line between the soft portion and that which was stony hard. The major portion of both lobes and the isthmus were removed.

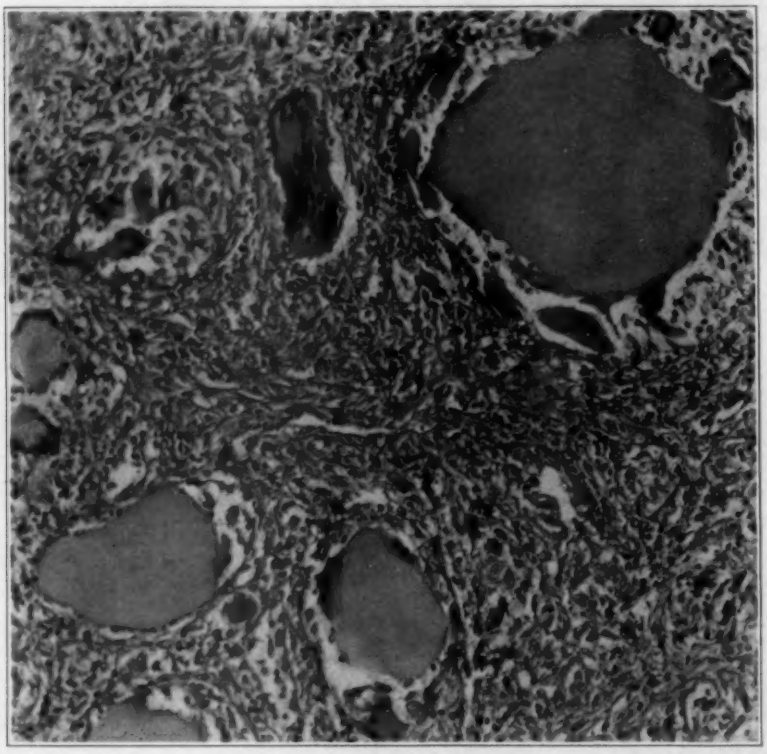

Fig. 4 (case 7).—A section of the thyroid gland in a case of thyroiditis (fibrous type). In this case the fibrosis is associated both with an inflammatory cell infiltration and with acinar destruction with phagocytosis of the colloid by multinucleated giant cells. This sometimes gives cell groupings resembling tubercles. Magnification, × 150.

Pathologic Report.—The specimen from the left lobe with the isthmus measured 4 by 2 by 1.2 cm. One surface, coarsely irregular, was covered by a thin capsule to which strands of connective tissue were adherent, suggesting adhesions. The tissue was very firm and cut with increased resistance. The cut surface showed coarse white fibrous trabeculae with intervening yellowish-pink areas. There was no recognizable colloid. No adenomas or areas of calcification were noted. The portion from the right lobe measured 3.5 by 2 by 0.8 cm. The major portion

of the capsule was covered with adherent fibrous tissue and a small portion of muscle. On section, this lobe was more densely fibrous than the left.

Microscopically, sections of the two lobes were essentially similar. The small amount of remaining thyroid parenchyma was represented by a few scattered acini lined by low cuboidal epithelium, for the most part poorly filled with colloid (fig. 4). The intervening areas were formed of dense fibrous tissue in which

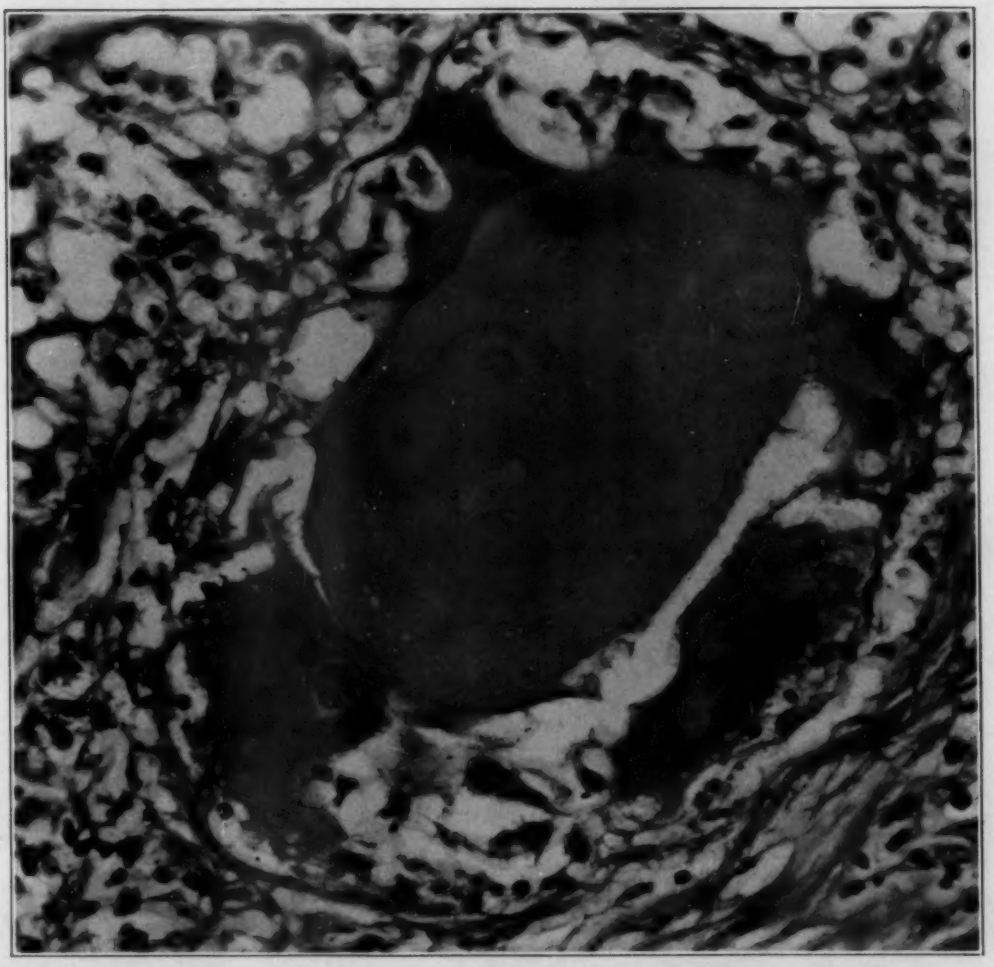

Fig. 5 (case 7).—A section of the thyroid gland in a case of thyroiditis (fibrous type) showing an acinus with complete disappearance of recognizable acinar cells and persistence of colloid and surrounding the latter syncytial multinucleated aggregates which are probably phagocytes. At the left is a vacuolated remnant of colloid. Lymphocytes and plasma cells are seen throughout the picture. Magnification, × 909.

there were many large multinuclear giant cells containing droplets of colloid. These had the appearance of being formed by fusion of several epithelial cells (fig. 5). There was extensive degeneration of the acini without hyperplasia of

the remaining ones. Many lymphocytes, plasma cells and polymorphonuclear leukocytes were present throughout the sections. No areas of necrosis or suppuration were noted. The fibrous and lymphocytic infiltration extended beyond the capsule into the surrounding muscle and fat. An adherent lymph node exhibited several hyperplastic germinal centers. Several large arteries outside the capsule showed calcification of the inner portion of the media. Tissue from the gland was injected into guinea-pigs, which at autopsy showed no evidence of tuberculosis.

Postoperative Course.—The temperature became normal on the third day and remained so. The patient was discharged on the eleventh day. The basal metabolic rate was —11. Six months after operation the weight was 139 pounds (63 Kg.); the pulse rate, 72, and the basal metabolic rate, —30. The patient felt tired and listless. The skin was not thickened. There was no loss of hair. Thyroid extract was prescribed. Two months later the patient was admitted to another hospital, unconscious. She remained five days and left against advice. The nature of the attack was unknown. There were no complaints. The pulse was regular; there were no signs of hypothyroidism, and the basal metabolic rate was —18. The basal metabolic rate one year after operation was —22. The patient did not have the appearance of a person with hypothyroidism. There was no evidence of recurrence.

Case 8.—*History.*—A married Negress, aged 43, was admitted to the hospital on July 8, 1931, with complaints of swelling of the neck of five years' duration, a loss of 25 pounds (11.3 Kg.) in weight in the previous year and nervousness of six months' duration. The family history was unimportant. The patient was born in British Guiana and had lived in the United States eight years. There was no history of a previous disorder of the thyroid gland. She had one child alive and well and had had no miscarriages. She had malaria from eight to ten years before admission and pleurisy three years before. She had enjoyed good health until the previous year, when she began to lose weight and noticed increasing nervousness. A mass had been present in the neck for five years. There was no pain, dyspnea or dysphagia.

Examination.—The temperature was 99 F.; the pulse rate, 82, and the respiratory rate, 20. The blood pressure was 155 systolic and 105 diastolic, and the weight was 124 pounds (56.2 Kg.). The patient was well developed and well nourished. There was no exophthalmos. The thyroid gland was easily palpable. It was firm, moderately enlarged and freely movable. There was no tremor or dyspnea, though slight tachycardia was noted. The regional lymph nodes were not enlarged. Because of the firmness of the gland, calcification of an adenoma was considered and also carcinoma and Riedel's strumitis. The basal metabolic rate was +12; the test for sugar in the urine gave a 4 plus reaction; the blood sugar content was 3.06 Gm. per liter. The red blood cells numbered 4,240,000, with 85 per cent hemoglobin; the white blood cells numbered 6,600, with 65 per cent polymorphonuclears, 33 per cent lymphocytes and 2 per cent monocytes. The Wassermann reaction was not recorded.

A diagnosis of adenoma of the thyroid gland (nontoxic), carcinoma (?), Riedel's strumitis (?) and diabetes mellitus was made.

Operation (Dr. W. B. Parsons; July 11).—The gland was symmetrically enlarged, particularly in the anterior direction, and was firm and white and felt calcified. The cut surface showed several raised circumscribed areas. A frozen section was made, and although a definite diagnosis could not be established it was thought that the condition was chronic thyroiditis rather than a malignant growth. The gland was not adherent. Half of the right lobe was removed.

Pathologic Report.—The specimen consisted of a portion of one lobe of the thyroid gland. It measured 3.5 by 2.5 by 2 cm. Two thirds of the surface was covered by a thin capsule. The gland was extremely firm but not stony hard. The cut surface was smooth and of a homogeneous pale grayish color. There were no areas of hemorrhage, degeneration, adenomas or calcification. The appearance and consistency were not those of carcinoma.

Microscopically, the sections showed a marked increase in fibrous connective tissue. For the most part this was hyalinized and formed coarse bands with inter-

Fig. 6 (case 8).—A section of the thyroid gland in a case of thyroiditis (fibrous with lymphoid infiltration). There is marked generalized fibrosis, with atrophy of acini and reduction in colloid and also a generalized lymphocytic and plasma cell infiltration, with the formation of occasional lymph follicles. Magnification, × 100.

vening strands. Numerous lymphocytes and plasma cells were present in the spaces. A few lymph follicles with hyperplastic germinal centers were noted (fig. 6). The acini were small and widely separated. Very little colloid was evident. The epithelial cells were cuboidal and pale-staining and did not show evidence of hyperplasia. Some of the acini were undergoing degeneration. A few giant cells were present, apparently formed of fused epithelial cells about droplets of colloid. There was nothing suggestive of tuberculosis, syphilis or a malignant condition.

Postoperative Course.—The patient was discharged on the sixth day and had fully recovered in four months. There were no symptoms of hyperthyroidism or hypothyroidism. The weight was 137 pounds (62.1 Kg.). The basal metabolic rate at six months was —4. There was slight hypertrophy of the remnant on the left side ten months after operation. The basal metabolic rate was +7. The patient was in excellent health twenty-seven months after operation. The weight was 137 ½ pounds (62.3 Kg.). The right lobe was now firm and rounded and was similar in appearance to that before operation.

Case 9.—*History.*—A woman, aged 49, was admitted to the hospital on Nov. 13, 1931, with the complaint of a lump in the right side of the neck, with pain of three weeks' duration. The family history was unimportant. The patient was born in Czecho-Slovakia but had lived in the United States for twenty-four years. She was married and had four children alive and well. There was no history relative to a previous disorder of the thyroid gland. The patient had enjoyed good health until five months before admission, at which time she first noticed that she was losing weight and strength and perspired profusely. These symptoms were of a mild nature until three weeks before admission, when she experienced pain at the angle of the jaw, which radiated to the right ear. She noticed a firm lump about the size of a walnut in the right side of the neck. A dry cough developed. There was no palpitation, dyspnea or dysphagia. She lost 15 pounds (6.81 Kg.) in weight in the previous three months.

Examination.—The temperature was 98 F.; the pulse rate, 88, and the respiratory rate, 20. The blood pressure was 140 systolic and 80 diastolic, and the weight was 127 pounds (57.6 Kg.). The patient was well developed and well nourished. There was a tender, firm swelling in the right lobe and the isthmus of the thyroid. The swelling moved on swallowing and was not attached to the skin or the deeper structures. The left lobe was slightly enlarged. There was no exophthalmos or tremor. Roentgenograms of the chest and skeleton were normal. The urine was normal and the Wassermann reaction was negative. The basal metabolic rate was +14. The red blood cells numbered 4,070,000, with 70 per cent hemoglobin; the white blood cells numbered 7,200, with 74 per cent polymorphonuclears, 20 per cent lymphocytes and 6 per cent monocytes. Because of the hardness of the mass, carcinoma was suspected, although Riedel's strumitis was also considered. A diagnosis of carcinoma of the thyroid was made.

Operation (Dr. L. Sloan; November 21).—The right lobe was unusually firm. The cut surface was dense white and homogeneous, resembling fibrous tissue. There were a few firm nodular areas on the surface with intervening softer areas. The left lobe was similar but smaller. A mold of the trachea was formed on the posterior surface of the gland.

Pathologic Report.—The specimen consisted of a portion of both lobes of the thyroid and the isthmus. These measured 7 by 4 by 2.5 cm. and 5 by 3 by 2 cm., respectively. Both were partially covered by a thin capsule which was torn in places. Both were similar in section. The tissue was firm and white, with areas of apparent thyroid parenchyma containing colloid. No adenomas were noted.

Microscopically, the sections showed great variation. In some areas there was a marked lymphocytic infiltration, with localized small follicles containing hyperplastic germinal centers. These sections contained very little fibrous tissue. The acini contained colloid and appeared compressed; some were degenerating. Other areas were composed chiefly of dense interlacing bands of hyalinized fibrous connective tissue, through which many lymphocytes were scattered. The acini in these areas showed varying degrees of degeneration and contained very little

colloid. Many multinuclear giant cells were present. These were formed apparently by fusion of epithelial cells and contained droplets of colloid. The epithelium was of the low cuboidal type and showed no hyperplasia. The areas which were largely fibrous were beneath the capsule, while the deeper areas were largely lymphoid. The sections were of unusual interest because they showed the two types of reaction previously not seen in one specimen. Fibrosis, however, predominated. No tubercles were present. An extensive search was made for tubercle bacilli in sections stained by the Ziehl-Neelsen method but none were found. The basal metabolic rate was —4 on the day of discharge, the seventh day.

Postoperative Course.—The patient felt well in one month and weighed 131 pounds (59.4 Kg.). The basal metabolic rate was —16. Two months later she had definite signs of hypothyroidism verging on myxedema. The skin was dry, the eyes puffy, the hair dry, the color pale and speech slow. The weight was 147 pounds (66.7 Kg.). The basal metabolic rate was —29. The patient was given thyroid extract. Five months after operation she felt well. The basal metabolic rate was —15, and she weighed 144 pounds (65.3 Kg.). When seen nine months after operation she was taking 5 grains (0.32 Gm.) of thyroid extract a day. The basal metabolic rate was —6. There were no signs of myxedema. The patient discontinued the thyroid extract without advice. When she was seen after eighteen months her weight was 153 pounds (61.2 Kg.) and signs of myxedema had returned. Her condition improved on medication with thyroid extract, and she was free from symptoms three months later. When last seen twenty-five months after operation she again showed signs of myxedema because of failure to continue treatment. There was no evidence of recurrence of the growth.

REPORT OF CASES OF THE LYMPHOID TYPE (HASHIMOTO)

CASE 10.—*History.*—A nurse, aged 26, was admitted to the hospital on Dec. 14, 1922, with the complaint of swelling of the neck of seven years' duration. Her father had died of pulmonary tuberculosis. She had enjoyed good health until six years before admission, at which time she suffered from bilateral dry pleurisy. Four years later she had an attack of jaundice, which lasted one month. During the year preceding admission she had frequent attacks of indigestion at night, with nausea, headaches and vomiting of bile-colored fluid, but no blood. These attacks lasted one day; they were not relieved by medication and frequently followed a heavy meal. The patient lost 14 pounds (6.4 Kg.) in weight during this period. Seven years before admission she first noticed swelling of the neck. This slowly increased in size without giving rise to symptoms for six years, following which she experienced a feeling of constriction in the neck, most marked when she was recumbent. This was accompanied six months later by palpitation, general muscular weakness and nervousness. During the months prior to hospitalization she noticed dyspnea and for two weeks intermittent pain along the posterior borders of the sternocleidomastoid muscles and across the neck in the region of the isthmus.

Examination.—The temperature was 99 F.; the pulse rate, 90, and the respiratory rate, 18. The blood pressure was 120 systolic and 80 diastolic. The weight was 123½ pounds (56 Kg.). The patient was well developed and well nourished and not acutely ill. There were no abnormal ocular signs. The thyroid gland was diffusely enlarged and extended beneath the sternocleidomastoid muscles. The isthmus was also enlarged. The swelling was firm in consistency and most marked on the right side. There was retraction of the wall of the chest in both

the supraclavicular and the infraclavicular region. A few persistent fine râles were heard at the apex of the left lung, in the left axillary region and at the bases of both lungs. Urinalysis gave negative results. The Wassermann reaction was negative. The basal metabolic rate was —5. Roentgenograms showed extensive calcification of both hilar regions and diaphragmatic adhesions suggestive of old tuberculosis.

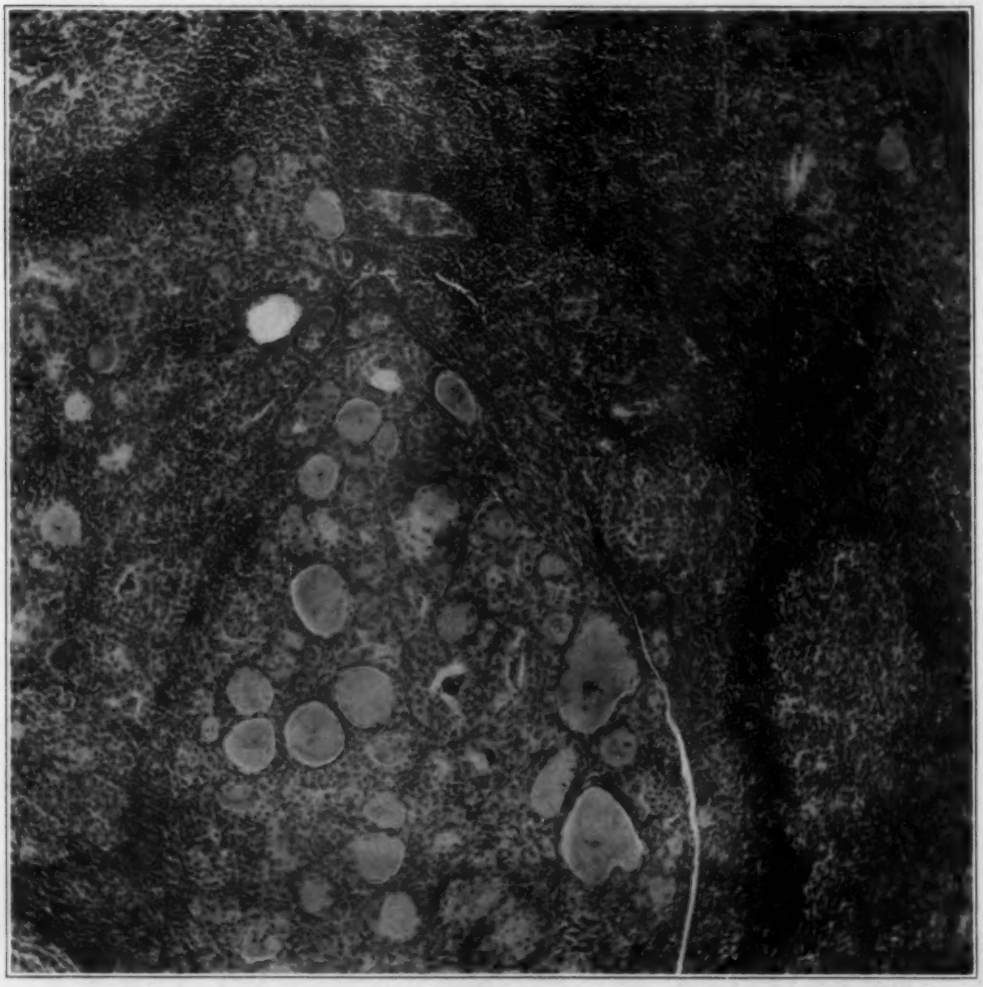

Fig. 7 (case 10).—A section of the thyroid gland in a case of thyroiditis (lymphoid type) showing numerous lymph follicles, lymphoid cell infiltration between the acini and apparent atrophy of acini with reduction of the colloid content. Magnification, × 227.

The patient was given 0.1 Gm. of sodium iodide a day by mouth for five weeks without any noticeable change in the mass.

A diagnosis of adenoma of the thyroid was made.

Operation (Dr. W. B. Parsons, December 16).—There was a moderate-sized diffuse enlargement of the right lobe of the thyroid gland, which felt like an adenoma but could not be easily enucleated. The major portion was removed. Bleeding was so profuse that packing was necessary to control it.

Pathologic Report.—The gross specimen consisted of four irregular pieces of tissue, the largest measuring 5 by 4 by 1 cm. and the others less than 2 cm. in diameter. They were composed in part of elastic pink tissue having the appearance of pancreas. In other areas they were of dense white tissue. On section they presented irregular pink areas and a few rather dense white areas. There were no cysts or colloid.

Microscopically, the sections of each portion were similar. There was an increase in the interlobular and intralobular connective tissue. This was densely and diffusely infiltrated with lymphocytes, which formed many large and small follicles containing hyperplastic germinal centers showing occasional mitotic figures. Scattered small groups of acini were seen. These were greatly distorted and appeared compressed. Very few were lined with cuboidal cells; most, however, were lined with small atrophic cells. The lumens of many were filled with large, swollen, pale epithelial cells. Very little colloid was present (fig. 7). No giant cells were seen. There were no areas of necrosis, suppuration or areas suggestive of tubercles. The blood vessels were free from pathologic change.

Postoperative Course.—The recovery was prolonged by an infected hematoma in the incision. The patient was discharged on the twenty-fourth day. She gained 9 pounds (4.1 Kg.) in three months and noticed a marked improvement in her nervousness. She was admitted to another hospital fifteen months after operation, where she died following an operation for duodenal ulcer. She had no symptoms relative to the thyroid gland at this time.

Case 11.—*History.*—A Jewess, aged 36, was admitted to the hospital on June 7, 1931, with the complaint of swelling of the neck of six months' duration. Her mother stated that she had had a slight swelling since puberty. The family history was unimportant. The patient was married; her husband and three children were alive and well. Four years before admission she was treated for a gastric ulcer with diet, which relieved the symptoms. Six months before her visit to the hospital she noticed a swelling in the midline of the neck. Two months later both sides became enlarged, and she experienced nervousness, palpitation at night, pain on the right side of the neck, attacks of choking and insomnia. There were no previous symptoms referable to the thyroid gland.

Examination.—The temperature was 99.6 F.; the pulse rate, 78, and the respiratory rate, 18. The blood pressure was 135 systolic and 95 diastolic. The weight was 172 pounds (78 Kg.). The patient was well developed and obese. There was no exophthalmos or ocular signs of hyperthyroidism. There was a marked diffuse symmetrical enlargement of the thyroid gland, which also involved the isthmus. The trachea was not displaced. A fine tremor of the fingers was noted. Urinalysis gave negative results. The Wassermann reaction was negative. The basal metabolic rate was —5. The blood count was not recorded.

A diagnosis of adenoma of the thyroid gland was made.

Operation (Dr. W. B. Parsons; June 11).—The thyroid gland contained several small adenomatous nodules. The pyramidal lobe and the isthmus were unusually thick. The lobes were rather friable but appeared to contain abundant colloid. A subtotal resection was done on both sides with removal of the isthmus and the pyramidal lobe.

Pathologic Report.—The specimen consisted of portions of both lobes of the thyroid gland which measured 6.5 by 6 by 2.5 cm. and 6.5 by 4 by 2 cm., respectively. They were similar in appearance. Each was partially covered by a thin capsule. They were firm in consistency, and the cut surface had a dull grayish-white cellular appearance. No cysts or adenomas were noted.

Microscopically, sections from various parts of each showed a marked infiltration of lymphocytes. There were many diffusely scattered, but for the most part they formed large and small follicles containing frequent hyperplastic germinal centers. The surrounding acini appeared compressed. These were lined

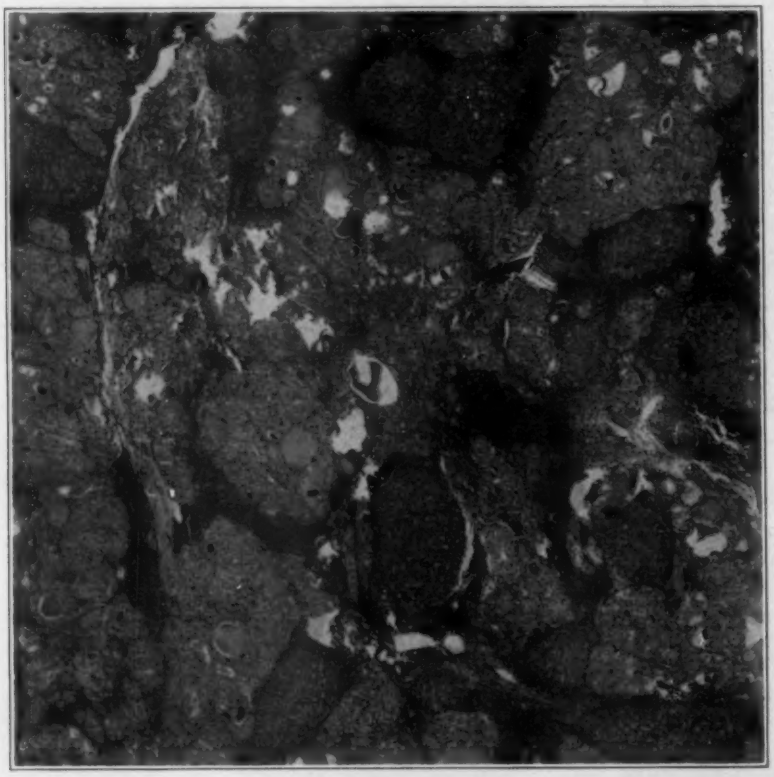

Fig. 8 (case 11).—A section of the thyroid gland in a case of thyroiditis (lymphoid type) showing the numerous lymph follicles and small acini with little colloid content. Magnification, × 100.

by swollen, pale cuboidal cells. The nuclei were round or oval and vesicular, with a large amount of pale granular cytoplasm. Very few contained colloid (fig. 8). There was a slight increase in the interlobular connective tissue stroma. The acini showed degeneration but were without evidence of hypertrophy or regeneration. No giant cells were noted. The vessels were apparently free from pathologic change.

Postoperative Course.—The patient was discharged on the sixth day. The basal metabolic rate was —4. Her general condition was improved in one month. She weighed 170 pounds (77.1 Kg.). She was free from symptoms two months

after operation. There was no evidence of hypothyroidism or hyperthyroidism one year after operation. A slight increase in the remnants of the gland was noted at this time. The gland was still palpable twenty months after operation, but there were no symptoms of recurrence.

CASE 12.—*History.*—An American housewife, aged 31, was admitted to the hospital on March 15, 1934, with complaints of a goiter of fifteen years' duration and nervousness of a few years' duration. Her mother had a nontoxic goiter, and a cousin had suffered from exophthalmic goiter. When the patient was 16 years of age a physician told her that she had a goiter. This did not give rise to symptoms, and did not enlarge until during the first pregnancy, three years later. Following this the swelling receded and continued to do so after a second pregnancy, although it did not decrease to the original size. The goiter slowly enlarged again after the third pregnancy, six years before admission. For a few years before admission the patient had been conscious of the growth when she was excited or nervous. These symptoms had become more marked recently. There was no pain, tremor, loss of weight, exophthalmos, dyspnea, dysphagia or symptoms of hypothyroidism. The basal metabolic rate was not elevated, a recent reading being —9.

Examination.—The temperature was 98.6 F.; the pulse rate, 84, and the respiratory rate, 22. The blood pressure was 112 systolic and 78 diastolic. The weight was 109 pounds (49.4 Kg.). The patient was well nourished and did not appear acutely ill. The thyroid gland was moderately enlarged, movable and firm, but not hard or tender. The enlargement was bilateral but was most marked on the right side and at the isthmus. The regional lymph nodes were not enlarged. There was no tremor or exophthalmos. The urine was normal. The Wassermann reaction and the blood count were not recorded.

A diagnosis of adenoma of the thyroid gland (nontoxic) was made.

Operation (Dr. L. Sloan; March 16).—"Contrary to expectations, the gland was not grossly nodular but diffusely enlarged and lobulated. It had the appearance of a gland such as usually occurs in primary hyperthyroidism; that is, it was pale, firm, friable and vascular. The enlargement was chiefly of the right lobe and the isthmus, but the left lobe was larger than normal. The gland was not adherent to the surrounding structures or trachea."

The major portion of the right lobe, the isthmus and a wedge-shaped piece from the left lobe were removed.

RÉSUMÉ OF TYPES

Fibrous Type (Riedel).—The onset of this type is insidious. The disease is characterized by the appearance of a hard tumor mass in the thyroid gland. Not infrequently a goiter may have been present for months or even years. This swelling, which has not given rise to symptoms, suddenly begins to enlarge rapidly, without apparent cause. The enlargement usually appears in one lobe and may remain localized, but more frequently it extends to involve the entire gland. The mass is of moderate size but tends early to become fixed to the surrounding structures and may even involve the mediastinum, but the skin rarely becomes adherent.

The symptoms seem out of proportion to the size of the tumor. Symptoms of pressure appear early, the most common being dyspnea,

which is most marked on exertion, and dysphagia, dysphonia and attacks of aphonia when the patient is recumbent. Nervousness and tachycardia, usually without tremor, may occur late. Pain is usually absent, but tenderness is not uncommon. The temperature is not elevated; the leukocyte count is normal. The basal metabolic rate remains within normal limits. The general health is not impaired. There are no associated signs of hypothyroidism or hyperthyroidism.

The tumor is extremely hard and likened to wood, iron, stone, cartilage and even bone. It is smooth or finely irregular. The edges are ill defined, especially as the tumor becomes fixed to the surrounding structures. The regional lymph nodes are not enlarged. Grossly, the capsule is usually thickened and fibrous. The gland is white and appears fibrous, and very little, if any, thyroid parenchyma can be recognized. Microscopically, this form is characterized by fibrosis, which varies in degree from marked accentuation of the interlobular and intralobular stroma to complete replacement of the parenchyma by hyalinized fibrous connective tissue. The fibrosis is usually most pronounced beneath the capsule and may extend to the surrounding structures. The remaining acini appear compressed and show varying degrees of degeneration with occasional evidence of epithelial hyperplasia. Numerous plasma cells are present. There is great variation in the numbers of lymphocytes. In many cases, of which the first six are examples, there are only small numbers of scattered lymphocytes. In cases 7, 8 and 9 there was a generalized lymphocytic infiltration with formation of follicles containing hyperplastic germinal centers. This is illustrated by figure 6. Large multinuclear phagocytic giant cells frequently occur in the areas of degenerating acini. These appear to be formed by fusion of epithelial cells around droplets of colloid (figs. 4 and 5).

Lymphoid Type (Hashimoto).—In contrast to the fibrous type, this form occurs almost exclusively in women. The disease manifests itself at the onset by the chance discovery of a goiter without symptoms of hypothyroidism or hyperthyroidism. Rapid enlargement usually occurs after several months. This is accompanied by symptoms of local pressure. Pain and tenderness are uncommon. The enlargement is due to changes within the capsule, and in contrast to the fibrous type the mass becomes adherent only to the trachea. There is no fever or leukocytosis. The basal metabolic rate is not elevated. The general health is not impaired.

The usual contour of the thyroid gland is preserved. The enlargement is hard, smooth and movable, and the boundaries are clearly defined.

Grossly, both lobes and the isthmus are uniformly enlarged and covered by a thin capsule. The tissue is hard and white and cuts with the resistance of fibrous tissue. The cut surface has a dense, homo-

geneous cellular appearance and is traversed by clearly defined fibrous trabeculae. Normal thyroid parenchyma or colloid cannot be recognized.

Microscopically, this type is characterized by massive and diffuse lymphocytic infiltration, with localized lymph follicles containing hyperplastic germinal centers. Plasma cells are also regularly seen. The acini show varying degrees of atrophy with degeneration of epithelium, diminution of colloid and replacement fibrosis. There is an increase in the fibrous stroma. There is nothing suggestive of tuberculosis, suppuration or a malignant growth. The vessels show no unusual change.

COMMENT

Comparison of the Two Types.—It seems correct to separate the cases into two groups because of clinical and pathologic differences. Beyond this, many difficulties are encountered in the interpretation of the two forms as separate diseases or as different stages of the same disease. The obscure etiology makes the problem one impossible to solve at the present time. It is the impression, from the study of twelve cases and the review of reported cases to date, that the two are probably separate diseases, and that struma lymphomatosa is not necessarily followed by fibrosis, nor is Riedel's struma necessarily preceded by the former.

Many obstacles occur in reviewing the literature. Several authors have tabulated reported cases, but no two have recorded the same entire group. In the review of each case, the following factors have been taken into consideration: sex, age, history of previous goiter, symptoms of previous or present hypothyroidism or hyperthyroidism, duration of present symptoms, description of the tumor clinically and, in case of operation, the nature of the cervical infiltration, the gross and microscopic pathologic picture and the clinical and postoperative course. One hundred and sixteen records of cases have been collected, including those just presented. Cases in which there were inadequate clinical or pathologic reports and cases mentioned in the discussion of papers were excluded.

Twenty-six cases seem similar to those described by Hashimoto and ninety similar to those described by Riedel. In the former group there was only one male patient, while in the latter group twenty-nine or 32.2 per cent were men. If, then, the lymphoid type is the early stage of the fibrous type, the cases of the latter occurring in men, which represent 32.2 per cent, must either not pass through the first stage or pass through it so rapidly as to be unrecognized.

Both types occur largely in the same age period. The youngest patient with the lymphoid type was 26, and the oldest, 75. The average age of the women was 47.6 years. The one man was 50. The youngest patient with the fibrous type was 23, and the oldest, 78.

It is of interest that 73 per cent of the first group and 71.2 per cent of the second group of cases occurred in persons between the ages of 30 and 60 years.

The average duration of goiter in the first group was thirty-five months, and in the second, twenty-eight months. The duration of the symptoms in the cases of the lymphoid type was 15.4 months as compared to 6.3 months in those of the fibrous type. This can be explained by the absence of cervical infiltration in the former, and hence slower development of pressure symptoms.

The involvement of the thyroid gland was bilateral in 100 per cent of the cases of the lymphoid type and in only 70 per cent of those of the fibrous type. If, then, the former is the early stage of the latter, regression must have occurred in one lobe in 30 per cent of the cases.

TABLE 1.—*Age Distribution of the Lymphoid and Fibrous Types*

	Age Period							
	20 to 30	30 to 40	40 to 50	50 to 60	60 to 70	70 to 80	?	Total
Lymphoid type (Hashimoto)								
Males	..	..	..	1	..	..	..	1
Females	2	5	8	5	3	2	0	25
Fibrous type (Reidel)								
Males	3	9	8	3	3	1	2	29
Females	7	15	20	11	5	0	3	61

TABLE 2.—*Comparison of Lymphoid and Fibrous Types*

	Lymphoid Type (26 Cases)	Fibrous Type (90 Cases)
Sex		
Male	1 (4.0%)	29 (32.2%)
Female	25 (96.0%)	61 (67.8%)
Age, years		
Youngest	26	23
Oldest	75	78
Average: Male	50	42.1
Female	47.6	43.6
Duration of goiter		
Shortest	3 days	30 days
Longest	14 years	26 years
Average	35 months	26 months
Number of cases	22	54
Duration of symptoms		
Shortest	30 days	15 days
Longest	6 years	2 years
Average	15.4 months	6.3 months
Number of cases	16	49
Thyroid involvement		
Bilateral	100%	70%
Unilateral	..	30%
Operative findings		
Diffuse cervical infiltration	0	80%
Postoperative hypothyroidism		
Percentage	40%	25%
Number of cases	22	63

In all the cases of the lymphoid type the process was limited by the capsule, with at the most only adhesions to the trachea, whereas in 80 per cent of the cases of the fibrous type there was diffuse cervical infiltration.

Postoperative hypothyroidism was more common in the cases of the lymphoid than in those of the fibrous type in the ratio of 40 to 25 per cent. This can be explained by the fact that it was surgically remarkable in the former group and hence was treated by more extensive excision than was possible in the cases of the fibrous type. This also explains cases of recurrence or persistence in the latter group, which required secondary operations not necessary in the former group.

Etiology.—The etiology is unknown. Tuberculosis and syphilis have been suspected as being factors but have been excluded by many. Numerous attempts to demonstrate tubercle bacilli and Spirochaeta pallida in the specimens have failed. Bohn reported a case followed by regression after removal of infected teeth with apical abscess from which "green producing streptococci and staphylococci" were cultured. Wegelin and Erkes have seen cases following "grip." Searles and Bartlett mentioned a case in which a strain of Streptococcus viridans, which was identical with an organism recovered from the patient's throat, was cultured from a biopsy specimen. Meeker reported a case in which the condition was associated with remnants of the postbranchial body in the thyroid gland, and suggested this as a possible route of infection. Tailhefer and Gerlak suggested the staphylococcus as a possible etiologic factor. Wegelin, however, mentioned the fact that cultures of the thyroid gland often show bacteria without any definite trace of inflammation being present.

Graham stated in 1931:

> The group of cases generally classified as Riedel's disease may be looked upon as a local inflammatory process in the thyroid for which an etiological factor should be sought. In these cases the general body economy is affected only secondarily by reason of destruction of the thyroid, interference with deglutition and injuries to important blood vessels and nerves. Such a process has its counterpart in other organs and tissues, which may be expected to react similarly, except for the fact that the thyroid is so situated that complications can occur readily. The changes which occur in the thyroid in the presence of the Hashimoto type of lesion, however, may be considered primarily as a local manifestation of a constitutional disorder, the nature of which is not yet understood. What the initial changes in the thyroid may be is not yet known, but it seems clear that in the course of time these changes tend to become degenerative (rather than inflammatory) and sclerosing, and ultimately may be accompanied or complicated by more definitely inflammatory phenomena of a nonspecific character.

Diagnosis.—The preoperative diagnosis is difficult but not impossible. The history of rapid enlargement and hardness of the tumor, and in

many cases fixation to the surrounding structures, immediately suggests a malignant growth, especially when the disease is limited to one lobe. However, when the lesion is bilateral (carcinoma being usually unilateral), movable or adherent only to the trachea and is tender and unassociated with hyperthyroidism, enlargement of the lymph node and impairment of health, chronic thyroiditis should be suspected. When possible, roentgenograms should be taken of the long bones to exclude metastases. Examination of frozen sections at the time of operation is recommended.

Treatment.—Local applications of heat, cold, iodine, x-rays and radium have not proved curative, and their value is questionable.

Conservative resection of the tumor with division or removal of the isthmus is the recommended treatment. Even removal of small portions can be expected to be followed by regression of the mass. For this reason radical excision should not be attempted.

SUMMARY

Twelve cases illustrating the clinicopathologic features of a rare disease of the thyroid gland are reported.

The etiology is unknown. The disease is not associated with hypothyroidism or hyperthyroidism and is obviously not a malignant new growth, as metastases never occur. Clinically, the condition is most frequently mistaken for carcinoma. The general health is not impaired other than from local pressure.

There are two distinct types: a fibrous and a lymphoid type.

The fibrous type manifests itself by the appearance of a hard tumor mass. This rapidly enlarges and may remain localized to one lobe but more often extends to involve the entire gland. Diffuse cervical infiltration with accompanying symptoms of local pressure occurs early. This form is characterized microscopically by diffuse fibrosis with a varying degree of lymphocytic infiltration. There is marked atrophy of the acini, with the formation of large multinucleated phagocytic giant cells.

The lymphoid type manifests itself by the sudden rapid enlargement of a goiter of several months' duration. The growth is bilateral and hard and becomes adherent to the trachea only. This form is characterized microscopically by a dense infiltration of lymphocytes and the formation of lymph follicles with hyperplastic germinal centers. Varying degrees of degeneration of the acini occur, with associated fibrosis.

The two types have been generally accepted as different stages of the same disease. It is the conclusion from the study of twelve cases and the review of reported cases that these forms are probably separate and distinct entities.

The course of the disease is benign. Total removal of the growth is not necessary. Partial conservative resection is the recommended treatment. Recovery with subsequent good health is to be expected. Recurrence is rare.

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A REVIEW OF UROLOGIC SURGERY

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KIDNEY

Anomalies.—Marcucci [1] reviewed the malformations of the urinary apparatus that may give rise to renal disorders. After making a detailed study he concluded that all such malformations may at times produce disease within the kidney. Every malformation has its own particular relation to the determination of pathologic change in the body; this is revealed in cases of renal changes which generally are the results of urinary obstruction. Some of them produce stagnation by mechanically obstructing the normal progress of the renal secretion; others apparently disturb the harmony of muscular action on which urinary excretion depends, since the calices, pelvis and ureter constitute a single dynamic, harmonic complex. Others express a constitutional deficiency, either myogenic or neurogenic, in the pyelo-ureteral excretory system; that is, in the various parts to which the transportation and regulation of the urine is delegated.

As is always the case with any organic fluid which becomes stagnant, the retained urine easily becomes infected and constitutes the basis for formation of calculi, which have a twofold effect: They increase retention by mechanically obstructing the urinary outlet, and they cause inhibition or spasm of the musculature of the ureter. Suppuration continues to impose a fatal burden on the already diminished functional and anatomic integrity of the renal apparatus. In proportion to the quantity of toxic elements that it brings into contact with the pyelo-

1. Marcucci, Guiseppe: Rapporti fra anomalie ed affezioni renali, Arch. ital. di urol. **11**:427 (Aug.) 1934.

ureteral musculature it induces spasms, hypertonia and retention, or it produces atony through degenerative changes that it brings about in the muscular tunics and leads to dilatation.

Stasis favors infection, and infection maintains stasis; the resulting retention, which increases progressively by virtue of these two factors reciprocally augmenting one another, is the expression of the continuous decadence of the excretory duct; this decadence is first dynamic, then anatomic, and is revealed in the kidney by nephritis, pyelonephritis, hydronephrosis, hydropyonephrosis, pyonephrosis and calculosis.

Tumors.—Priestley and Broders [2] reported that Wilms' tumor, also called embryoma or embryonal adenosarcoma of the kidney, was diagnosed in 65 cases at the Mayo Clinic. Thirty-seven of the patients gave evidence of advanced disease at the original examination and received irradiation or symptomatic treatment alone. The remaining 28 were subjected to operation, 20 undergoing nephrectomy. Forty-four of the 65 patients were followed. Clinical evidence of this disease usually becomes manifest only after advanced pathologic changes have taken place in the kidney. An abdominal mass in the region of the kidney involved was the most common initial complaint (in 40.5 per cent of the patients it occurred as the initial symptom), and it was present in all but 1 patient at the time of examination at the clinic.

According to Priestley and Broders the differential diagnosis of Wilms' tumor seldom affords much difficulty, although occasionally hydronephrosis, polycystic kidney, solitary cyst of the kidney and various retroperitoneal tumors may be confused with this lesion. To mistake the condition for hydronephrosis is the most common error in diagnosis, as in both this condition and in Wilms' tumor a cystic-feeling mass, associated with fever, may be present. Gradual growth of the mass and hematuria indicate the presence of a neoplasm. The two most valuable aids in establishing the diagnosis of Wilms' tumor are intravenous urography and the fact that there is remarkable diminution in the size of the mass after roentgen therapy.

Considerable divergence of opinion exists regarding the proper method of treatment of this type of tumor. Some authors favor irradiation alone and regard nephrectomy only as a procedure that promotes early metastasis; others hold an opposite opinion. Priestley and Broders expressed the belief that the most satisfactory treatment includes preoperative roentgen therapy, followed at an appropriate time by surgical removal of the lesion and subsequently by irradiation. The amount of roentgen treatment used preoperatively is regulated by the dose tol-

2. Priestley, J. T., and Broders, A. C.: Wilms' Tumor: The Most Common Malignant Growth Affecting Children, Proc. Staff Meet., Mayo Clin. **10**:81 (Feb. 6) 1935.

erated by the patient and by the therapeutic response, as evidenced by decrease in the size of the tumor. At least one course of treatment should be given, and sometimes a second series is indicated. The optimal time for operation exists when the maximal therapeutic response has been obtained and is prior to a secondary increase in the size of the tumor. This usually requires a period of from three to six weeks. Excessive irradiation may be detrimental to the normal development of children.

The results of treatment of Wilms' tumors in the past have been discouraging. Of the 44 patients in this series who were followed, 40 are dead, and not a single patient is living who was treated by irradiation only. Of the 4 patients who are living at present, 1 has survived thirteen and a half years; 1, three and a half years, and 2, ten months each. Since the introduction of combined irradiation and surgical treatment in cases of Wilms' tumor more favorable results have been obtained.

Taylor [3] stated that the etiology of papillary carcinoma of the pelvis is not known. Chronic irritation in the pelvis probably accounts for initiation of these growths. Few papillary growths have followed chronic infections and calculi have been associated with only about 5 per cent of such growths. In the nonpapillary group of tumors infections, leukoplakia and stones have played a much more prominent rôle as possible exciting factors. The chief characteristic of papillary tumors of the pelvis is surface metastasis. This is evident clinically. According to Taylor, Stricker reviewed 175 cases of papillomatous tumor of the renal pelvis and found that the same type of tumor was found concurrently in the ureter and in the bladder in 47 per cent of the patients. In 35 per cent of cases in which nephrectomy was performed for papillary tumor of the pelvis recurrence in the ureter or bladder appeared later. Taylor referred to Kimball and Ferris, who in a similar study found 74 cases in the literature, in 50 of which tumors occurred in the ureter or bladder after nephrectomy; they also found 24 cases in which the ureter and bladder were affected at the time of examination or operation. Hematuria is the most frequent and usually the first symptom. It is the only symptom in about one fourth of the cases. It is present some time in the course of the disease in 70 per cent of cases of papillary tumor of the pelvis. Because of the marked vascularity of the tumors they usually bleed early, abundantly, intermittently and without any exciting cause. Pain is a variable symptom and depends on distention of the pelvis, which in turn is attributable to obstruction, either by clot or tumor, at the ureteropelvic juncture. Lumbar aching or discomfort may be annoying; it is usually a distention type of distress

3. Taylor, W. N.: Papillary Epithelioma of the Renal Pelvis, J. Urol. **33**: 531 (June) 1935.

and is attributable to the associated hydronephrosis. Ureteral colic may result from the passage of either blood clots or fragments of tissue from the tumor. The passage of particles of tissue is another clinical finding which may be indicative of the lesion. These particles may be found in the urine, or the patient may recall having passed such particles. Vesical symptoms depend on irritation complicating the lesion. Frequency, dysuria and inability to void are usually attributable to stone, infection or blood clots in the bladder. Constitutional symptoms, such as loss of weight, anemia and asthenia are late manifestations and are usually associated only with metastasis. The lesion is practically never diagnosed from the history, the symptoms or the physical examination. Cystoscopy is of definite value only when there are tumors in the bladder, and these are presumptive evidences only when they are situated about, or are protruding from, the ureteral orifice of the involved kidney. The tendency to implantation on the mucosa of the ureter and bladder demands surgical removal of the kidney, ureter and a section of the vesical wall for complete eradication of the disease.

Sprenger and Bohrod [4] reported 2 cases in which the presence of bilateral renal carcinoma was proved at necropsy, together with certain clinical findings, and reviewed the literature concerning bilateral renal new growths of this type. The literature shows that this condition occurs rarely. Sprenger and Bohrod stated that Chute, in 1926, reported 43 cases of renal carcinoma including 1 in which involvement was bilateral and that Sanford reported a case in which there was carcinoma of both kidneys and in his studies found 4 similar cases.

Necropsy in the first case reported by Sprenger and Bohrod revealed that the right kidney was about one and a half times normal size. Near the hilus there was a fairly well encapsulated tumor 5.5 cm. in diameter. It was soft, and its cut surface was mottled with red areas of hemorrhage on a bright yellow background. Neither the pelvis nor the renal vein was invaded by the tumor, although the pelvis was compressed and markedly distorted. The region of the left kidney and the entire retroperitoneal space between the vertebral column and the lateral abdominal wall were occupied by a large tumor. On section, about three fourths of the mass was seen to be composed of an enormously enlarged kidney, the hilus and most of the upper pole of which were occupied by soft yellow tumor tissue. The pelvis was dilated and filled with pus. The ureter was thickened but free from tumor tissue. In the upper lateral portion of the kidney the tumor had broken through the capsule, and all the perirenal tissues were invaded by the tumor. The renal vein was free from tumor tissue. There was no metastasis anywhere. The

4. Sprenger, Arthur, and Bohrod, M. G.: Bilateral Renal Carcinomas, J. Urol. **33**:427 (May) 1935.

histologic appearance of the two tumors was alike, even in its variability. In most places the tumors were composed of large, clear cells filled with lipoid. In other places the cells were granular, stained more deeply and gave evidence of much more anaplasia. In these portions, especially, there were greatly dilated blood sinuses. Distinct papillary structures were present in both tumors, often occurring in the same slide with hypernephroid structures. Areas of necrosis and hemorrhage were numerous.

In the second case necropsy revealed that both kidneys were the sites of tumors. The hilus of the left kidney pointed directly anteriorly. The lower pole was occupied by an irregular tumor which, on section, was seen to be made up of two incompletely separated portions. The internal portion was composed of white tissue with a necrotic, gelatinous center. The external part was much firmer and of lighter color. Small, cystic portions and regions of hemorrhage were present. The right kidney was larger than the left. Most of the middle segment and almost all of the lower pole were occupied by an irregular tumor. On section this tumor was seen to be lobulated, bright yellow, with cystic portions and small regions of hemorrhage. The renal vein was short and filled by the same kind of tumor tissue. Metastatic growths were found in small number but were present in many organs. By direct extension from the left kidney, the tail of the pancreas was involved. There were several small, metastatic nodules in the body of the pancreas and a few large metastatic growths in the liver. Both adrenal glands contained metastatic growths. In the lung there was a single tumor nodule. The histologic appearance of the metastatic nodules was remarkably constant. The cells were large and clear, with small pyknotic nuclei. They were separated into groups by thin trabeculae of connective tissue. The cytoplasm was filled with lipoids. Areas of necrosis were common. The tumors in the two kidneys evidenced much variability. Although they were mainly composed of large, clear cells filled with lipoid, there were also many irregularly arranged and some giant-sized tumor cells. Large, blood-filled sinuses gave to some sections an appearance of pseudohemangiomatosis. The variability in the tumor of the left kidney was greater than that in the right.

According to Sprenger and Bohrod, the presence of bilateral renal carcinoma leads to some interesting considerations with regard to the pathogenesis of renal tumors. Multiple tumors are no longer considered to be as rare as they seemed to be in the past. Collections of large statistics appear to indicate that they are more frequent than they would be if they could be accounted for only by coincidence. This may indicate that some persons have a specific tendency to neoplasia. In the first case reported herein, in addition to the two tumors of the kidneys there were multiple hemangiomas in the skin, a hemangioma in the liver

and a benign adenoma in one kidney. Bilateral renal tumors, except for embryonal tumors and multiple tumors occurring in sclerotic kidneys, are exceedingly rare, and their rarity is especially noteworthy when it is realized that renal tumors are common.

In the genesis of every malignant tumor there is interplay of two distinct factors, an intrinsic one, the hereditary substratum, and an extrinsic one, the stimulus which is directly responsible for the malignant transformation of a hitherto quiescent cell or group of cells. The kidneys are protected against localized external influences. Stimuli which may come through the urine influence all parts of the kidney equally and simultaneously. Sprenger and Bohrod assumed that in some way the two kidneys are different at birth. The only difference lies in the presence of localized accumulations of embryonic cells arranged to form the so-called adenomas such as are found relatively frequently by accident at necropsy, but which may, as in 1 of their cases, be microscopic. The rare occurrence of bilateral renal carcinomas is, therefore, support for the contention that these tumors arise from embryonic cell rests or from benign adenoma-like nodules. The occasional occurrence of bilateral or multiple tumors is probably associated with the presence of multiple rests.

Waters [5] stated that tumors of the hypernephroma type and embryonal carcinomas are radiosensitive. Papillary carcinomas of the renal pelvis and the malignant, papillary cystadenomas are radioresistant. Irradiation has caused marked reduction in the size of radiosensitive renal tumors and has rendered operable tumors which had been inoperable because of their large size. Irradiation has produced in sensitive tumors extensive morphologic changes characterized by alterations in cellular structure, extensive fibrosis hyalinization and necrosis. The cells become shrunken. The cytoplasm may contract around the nucleus, and in certain cases the tumor has been completely destroyed and replaced by fibrous tissue. Palpation of the tumor should always be avoided as much as possible to prevent expressing tumor cells into the blood stream. Reduction begins almost immediately after institution of irradiation and continues for several weeks after cessation of treatment. Operative removal is imperative and should be performed within a few weeks after either the first or second series, depending on the degree of shrinkage of the tumor as revealed by palpation and retrograde pyelographic studies. Regrowth of the tumor may, and has, occurred after too long delay of operation. Preoperative irradiation has not made operation more difficult. In order to lessen the mortality in cases of tumor of the kidney an early diagnosis must be made. Great significance must be

5. Waters, C. A.: Preoperative Irradiation of Cortical Renal Tumors, Am. J. Roentgenol. **33**:149 (Feb.) 1935.

attached to hematuria and pain. The retrograde pyelogram helps to distinguish between pelvic and cortical tumors in from 80 to 100 per cent of the cases, and, in Waters' experience, 93.4 per cent of all cortical renal tumors have been radiosensitive.

Wharton [6] stated that a review of the literature shows that results of the surgical treatment of renal tumors are unsatisfactory. From 5 to 10 per cent of such tumors are considered inoperable because of size or metastasis, and in from 12 to 26 per cent of the cases nothing is done after exposure for the same reasons. The mortality from surgical shock after nephrectomy is between 15 and 30 per cent, and cure is permanent in less than 10 per cent of the remaining cases. Ninety per cent of children with renal tumors die within the first year after operation.

The unsatisfactory situation is caused largely by the fact that these tumors at the time of operation are large and friable and have thin capsules. The manipulation necessary in removing these enormous masses results in showers of distant metastatic growths and rupture of the capsule, with local recurrence. There are also technical difficulties because of the size of the tumor, with accompanying shock, hemorrhage and injury to important contiguous structures.

Wharton recommended preoperative irradiation to reduce the size of the tumor and the transperitoneal approach to minimize handling and to permit ligation of the renal vessels as the first step in removal of the tumor. Preoperative irradiation causes a rapid and striking reduction in size of the growths, especially of embryomas of children, and permits satisfactory surgical removal. During the three weeks' course of radiotherapy and there must be careful medical supervision, and a special diet, rest, tonics and transfusions are prescribed when necessary.

Wharton reported his experience in several cases which he divided as follows: Group 1 was composed of 2 cases of massive tumor in which preoperative irradiation was not given. Group 2 included 3 cases in which massive tumors were removed after preoperative irradiation. Group 3 was made up of cases in which small tumors were removed without irradiation.

Wharton [7] described and illustrated the steps of a simple method of performing transperitoneal nephrectomy, which makes it possible to remove malignant tumors of the kidney with a fair degree of safety and a minimal likelihood of rupturing the mass. This procedure tends to dissipate the current opinion that transperitoneal nephrectomy is a dangerous and complicated operation. It is Wharton's opinion, and also

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6. Wharton, L. R.: Preoperative Irradiation of Massive Tumors of the Kidney, Arch. Surg. **30**:35 (Jan.) 1935.

7. Wharton, L. R.: Transperitoneal Nephrectomy for Malignant Tumors of the Kidney, Surg., Gynec. & Obst. **60**:689 (March) 1935.

that of many other surgeons, that transperitoneal nephrectomy is safer than lumbar nephrectomy for removal of tumors of the kidney. Preoperative irradiation makes it possible to remove surgically many of these large tumors by reducing their size appreciably.

Bothe [8] stated that the embryonal sarcomatous cells of mixed tumors of the kidney are radiosensitive, whereas the epithelial cells in mixed tumors of this organ are radioresistant. When a mixed tumor of the kidney is irradiated before surgical removal the size of the neoplasm is usually reduced. This decrease in size of the growth following roentgen treatment appears to be dependent on the amount of embryonal sarcomatous tissue. Irradiation of the tumor does not completely destroy all the malignant cells. Mixed growths of the kidney should always receive sufficient preoperative irradiation and be removed afterward. Surgical delay results in subsequent growth and metastasis.

Dos Santos [9] stated that there are cases in which arteriography may clear up diagnoses that are indecisive in cases in which pyelography is insufficient. These are, especially, cases in which the diagnosis may be between renal or pararenal tumor on the one hand, and hydronephrosis or hematuric nephritis on the other. There are cases of hydronephrosis in which catheterization of the ureter is impossible and cases of hematuric nephritis in which pyelography gives somewhat doubtful results, making it impossible to affirm whether or not a neoplasm is present. It is, therefore, well worth while to note what arteriography can reveal with reference to tumors of the kidney.

There are three essential classes to be recognized in arteriographic study of tumors: hypernephromas, other cancers and vascular tumors. Hypernephromas, in the arteriogram, give images of ischemia by the side of vascular networks of the unaffected renal tissue. The larger the tumor, the more reduced will be the preserved parenchyma. Other types of malignant neoplasm, not hypernephroma, are more strongly vascularized, giving the image of an irregular circulation composed of newly formed vessels, such as dos Santos [10] has described elsewhere. It is not the hyperemia of inflammatory states, attributable to vasodilatation of a preexisting vascular network, but a new, improvised network, in which the course and also the lumens of the vessels are irregular, interrupted here and there by images corresponding to lakes of blood.

The aspect presented by vascular tumors (angiomas) is illustrated by a case in which the arteriogram revealed a bilaterality of the lesions,

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8. Bothe, A. E.: Tissue Changes in Mixed Tumors of the Kidney After Roentgen Therapy, J. Urol. **33**:434 (May) 1935.

9. dos Santos, Reynaldo: L'aortographie dans les tumeurs rénales et pararénales, Arch. d. mal. d. reins **8**:313 (May) 1934.

10. dos Santos, Reynaldo: Tumeurs malignes des membres, Paris, Masson & Cie, 1932.

unsuspected before. The most striking feature in the stereo-arteriogram was the abnormal development of the circulation of the left kidney, the dilatations and lakes of blood which reached two large branches of the renal artery, only the lower pole of the kidney appearing normal. In the right kidney, unexpectedly, a similar neoplastic aspect involved one branch of the renal artery; only at the poles was this kidney normal. The belief that this was a case of vascular tumors involving both kidneys, in which only the tumor of the left side had been diagnosed previously, was confirmed by exploratory laparotomy.

The impressive difference between these images and those of tuberculosis, hydronephrosis and, most of all, hematuric nephritis, makes clear the interest that this method has in relation to the symptomatology of renal neoplasms. It is true that the arteriogram in cases of hydronephrosis often resembles that in cases of hypernephroma, the ischemia comparing with the occasional enormous development of the tumor, but the ischemia of hydronephrosis extends throughout the kidney just as does the sclerosis and atrophy of the distended parenchyma, while in cases of hypernephroma one can always recognize a part of the kidney that is entirely spared, the normal vascular network contrasting with the ischemia of the neoplastic zone.

But it is in differential diagnosis between hematuric nephritis and renal tumors that this new method plays its most important rôle. Dos Santos described several illustrative cases, in which the presence of a tumor was ruled out by the absence of the characteristic neoplastic ischemia and the absence of any abnormality in circulation; hence the diagnosis of hematuric nephritis was established.

Not only in the diagnosis of renal tumors but also in the diagnosis of pararenal neoplasms does arteriography give decisive information, and not only with reference to the existence of a tumor, but also as to its localization, differentiating, on the right side between the kidney and liver or gallbladder, and on the left, between the kidney and spleen. The images of hydatid cysts of the liver and of splenomegaly, that dos Santos has described on a previous occasion, suffice to show that in doubtful cases a diagnosis may be reached easily. Any pararenal tumor, whether of the liver, spleen, pancreas or bed of the kidney, may, by compressing the renal pedicle, cause an ischemia which lowers the functional capacity of the parenchyma without the kidney's being the seat of the trouble. Functional tests must therefore be interpreted in the light of these possibilities, which arteriography has revealed. This compression of abdominal or pelvic vessels by tumors is a fact of a general order which arteriography has made it possible to point out from the beginning of these researches. Finally, in cases of retroperitoneal pararenal tumors, in which it is difficult to establish a differentiation from

renal tumors, arteriography is the surest means of identifying the situation, and sometimes the nature, of the neoplasm. Thus, in an illustrative case, pyelography disclosed marked deformation and distention of the calices, suggesting that the tumor was indeed renal, and in addition renal function as evidenced by excretion of indigocarmine was diminished on the side of the tumor, but arteriography disclosed that both left and right renal arteries were normal, and the contour of the kidney on the side of the tumor was also absolutely normal and incompatible with a tumor of the kidney. The tumor, probably a hydatid cyst, was, therefore, extrarenal, pushing the kidney downward and inward. Other illustrative cases also serve to reenforce the view that renal arteriography is a method that should claim the attention of every urologist.

Beer [11] reported on five-year cures in cases of neoplasm of the bladder and kidney in which treatment or operation was performed before 1930. Considerable confusion has been introduced into the study of end-results of treatment in cases of tumor of the bladder as a result of attempts at grading the malignancy of the tumors. Eleven patients who had noninfiltrating carcinomas were cured by transurethral fulguration or electrocoagulation with high frequency current; this number of patients represented 55 per cent of the total so treated and not lost to observation. Four patients who had noninfiltrating or moderately infiltrating papillary carcinoma were cured by transurethrally introduced radium, usually together with electrocoagulation; they represented 11 per cent of the total so treated and not lost to observation. Ten patients who had infiltrating, papillary carcinomas involving the wall of the bladder more or less diffusely were sucessfully treated by operative excision; they represented 55.5 per cent of the total in this classification and surviving the operation. Fourteen patients who had infiltrating, solid, ulcerating, more or less papillary carcinomas diffusely involving the wall of the bladder were satisfactorily treated by extensive resection, frequently with reimplantation of the ureter, 40 per cent of the total so treated surviving the operation. Two patients who had the same type of carcinoma were cured by suprapubic cystostomy and implantation of radon seeds, 10 per cent of the total so treated surviving the operation. Four patients who had extensive, solid, ulcerating, more or less papillary carcinomas diffusely involving the wall of the bladder were cured by total cystectomy, 57 per cent of the total so treated surviving the operation. With cauterization—diathermy or electric cautery, or Paquelin cautery—and high voltage roentgen therapy, there were no five-year cures among patients with carcinoma infiltrating more or less diffusely the wall of the bladder.

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11. Beer, Edwin: Some Remarks on Five Year Cures in Malignant Tumors. Surg., Gynec. & Obst. **60a**:479 (Feb.) 1935.

There was a total of 45 cures among patients with definite carcinoma treated before 1930. Owing to the advanced age of many of these patients when they presented themselves for treatment, their life expectancy scarcely warrants a five-year survival, and many more patients in each category were apparently cured, as there was no evidence of recurrence for periods of less than five years but sufficiently long to assume that cure had taken place.

According to Beer, the results in cases of malignant degeneration of the kidney must be divided into two categories: (1) hypernephroma or clear cell carcinoma, adenocarcinoma, papillary and squamous cell carcinoma of adults, and (2) embryoma, Wilms' tumor and sarcoma usually observed in children. There were no five-year cures in cases of Wilms' tumor or embryoma of children before 1930. One child with a hypernephroma was cured for more than five years, making the percentage for this group of 7 cases in which nephrectomy was performed only 16.66. Among adults, before 1930 there were 7 five-year cures among patients who had tumors of the kidney of the hypernephroma and adenocarcinoma and papillary carcinoma types, 1 five-year cure in a patient with a large embryoma or tumor of the Wilms' type and 1 five-year cure in a patient with a carcinoma of the ureter; 9 patients in all out of 34 survived the operation and were followed, making more than 26 per cent.

Stone.—Stevens [12] stated that the presence of calculi simultaneously in the upper parts of the two urinary tracts is not uncommon. There is no dependable method of dissolving calculi, but stones may pass spontaneously through the urinary channels or be removed by operation. Large, noninfected, nonobstructing, symptomless, stag-horn calculi are usually left alone. There is also questionable advantage in trying to remove a largs mass of nonobstructing, symptomless, small stones occupying an entire kidney; it is nearly impossible to find all of them, even with roentgen control at the operating table, and the kidney is usually mutilated in the attempt. It is not necessary to operate early for small, symptomless stones in a kidney, even in the presence of low grade infection, whereas it is not advisable to wait any considerable time for spontaneous passage of calculi of the ureter associated with infection of the urine. Stones of moderate size that are trapped in a calix need not be disturbed unless there is also persistent infection or unless symptoms are present.

The reasons for operating in cases of urinary lithiasis are that calculi of the upper part of the urinary tract are a serious menace when they obstruct urinary flow; they are potent in prolonging infection, and they

12. Stevens, A. R.: Bilateral Urinary Calculi with Special Reference to Therapeutic Problems, J. A. M. A. **104**:1289 (April 13) 1935.

may cause pressure atrophy of the parenchyma by growth of the stone. Ureterotomy is one of the less hazardous major operations. Pyelotomy entails added risk, and nephrotomy, particularly if extensive, is even more dangerous.

Stevens concluded, from a study of the literature and a review of 35 cases of bilateral urinary calculus in which operation was performed, that operation may not be advisable, or may be performed primarily on both sides or on one, depending on conditions. Treatment of lesions of this type must not be by stated rules and formulas, such as those which advise to operate first on the side of the better kidney, or of the worse kidney, or of the most recent pain; it must depend on definite knowledge of the immediate and remote objectives sought, of the means of attainment of these objectives, and of the risks involved. Improvement of renal function, primarily and eventually, control of infection and alleviation of symptoms should be sought. The first motive is usually outstanding, but relief from acute infection may demand initial attention, even nephrectomy.

Swick [13] stated that the usual history in cases of bilateral calculus of the urinary tract consists of recurrence, infection and renal insufficiency. For these reasons and because of difficulties encountered in coping with this problem, every attempt at conservative measures directed toward maintenance of renal reserve, both in the diagnosis and in the preoperative and postoperative care, must be made. Because practically all bilateral renal calculi are mainly composed of calcium phosphate and oxalate, and are therefore radiopaque, retrograde pyelography not only becomes unnecessary in many cases of such calculi but may be dangerous to the renal reserve. In cases of bilateral renal calculosis, in which in many instances the renal reserve is already compromised, retrograde pyelography may be the turning point in bringing about either uremia or urosepsis or both. Since the stag-horn, soft and fragmented type of stone is often encountered in cases of bilateral calculus of the kidney, the advantage of roentgen control at the operating table, as an adjuvant in the handling of such cases, is apparent.

Treatment of the patient should not end with the operation but should be followed along lines such as administration of the vitamin A diet; consideration of the possible relationship of hyperparathyroidism to renal calculi; recognition of the importance of constant forced intake of fluids; investigation of the reaction of the urine and the chemical composition of the stone removed, which should be determined in order to prescribe diets and medication more intelligently and, finally, in the presence of infection after removal of stones, use of the ketogenic diet.

13. Swick, Moses, in discussion on Stevens.[12]

Cahill [14] stated that calculous anuria, the condition that accompanies suppression of urine caused by stone in the kidney or ureter, occurs under the following circumstances: Two secreting kidneys may have both ureters or pelves blocked, either synchronously or one after the other; a single secreting kidney may be blocked, the other being imperfectly developed, having been destroyed by disease or having been previously removed; both kidneys or a double kidney may have a fused, single ureter, which may be blocked by a calculus; of two kidneys, apparently normal, one may be blocked and the other may fail to secrete because of reflex reactions, the so-called renorenal reflex block, that are set up. Cahill added an analysis of 22 cases of this disease, from the Squier Urological Clinic, to the collection of 355 cases obtained from the literature by Rubritius. Among the 377 cases of calculous anuria, bilateral calculi occurred in 92 cases (24.4 per cent), unilateral calculi with disease of the opposite kidney in 45 cases (11.9 per cent), unilateral calculi with the condition of the opposite kidney being unknown in 53 cases (14 per cent), unilateral calculi with the opposite kidney being absent, removed or aplastic in 128 cases (33.9 per cent) and unilateral calculi with reflex inhibition of the opposite kidney in 59 cases (15.6 per cent).

Diagnostically, the pain and anuria have been the most significant symptoms. Cystoscopy, in conjunction with pyelograms made after retrograde injection pyelograms, was the most important diagnostic procedure. Intravenous urograms were not satisfactory. The kidneys that failed to excrete the dye gave no shadows on the roentgenogram. In 9 of the 22 cases (40 per cent) there was no shadow of calculus on the roentgenogram of sufficient density to allow a diagnosis to be made. Relief of the obstruction is the first step in the treatment of calculous anuria. The various procedures used for this were cystoscopy and extraction of the calculus, insertion of a ureteral retention catheter past the obstruction with subsequent extraction of the calculus, ureterotomy with removal of the calculus, pyelotomy with removal of the calculus, and nephrostomy, single or double, with or without removal of the calculus.

In cases of bilateral obstruction, the operation on both sides was performed at one sitting. The kidney obstructed last was operated on first in each instance. After relief from obstruction there were marked changes in the patient's symptoms. Before operation the patient usually had a dry skin and lacked thirst; after operation there was profuse sweating and return of thirst. In the cases in which no infection was present there was rapid secretion of urine and elimination of the retained

14. Cahill, G. F.: The Medical and Surgical Treatment of Calculous Anuria, J. A. M. A. **104**:1306 (April 13) 1935.

urea from the blood. In the cases in which infection was present secretion often did not start until twenty-four or forty-eight hours after nephrostomy.

In the recovery of patients with calculous anuria the underlying principles appear to be the ability of the kidney to overcome the infection and to restore or improve its physiologic function. Sufficient proof has been given, experimentally and clinically, that a short block does not appreciably injure a kidney. In the early treatment in these cases the profuse forcing of fluids by subcutaneous and by intravenous administration of solutions of dextrose in various concentrations has been of value clinically to bring about the return of renal secretion. If secondary anemia was present in the patients with infection the renal output rose rapidly as the content of blood was restored toward normal. This was accomplished by means of transfusions of whole blood. In some cases, restoration of renal secretion followed only transfusion. In Cahill's experience renal lavage has not been followed by satisfactory results. It has prolonged the fever and symptoms in cases in which infection has been present and has not proved of value in the prevention of recurrence.

Trattner [15] stated that of 157 patients with lithiasis of the urinary tract admitted to the Cleveland City Hospital, 14 were found to be partially or completely anuric. Eight of the 14 were moribund when first observed and died shortly afterward. It is apparent that partial or complete suppression of urine in the presence of lithiasis is an emergency problem.

Decapsulation of the kidney would be of benefit if the kidney should be under tension, for the renal capsule is reflected from the vessels at the hilus and mechanically retards the venous flow from the kidney when stretched. Decapsulation may also be of value in permitting cortical abscesses of the kidney to drain. When the kidney is buried in dense adhesions it is much safer to mobilize it intracapsularly, particularly on its anterior surface, than to attempt a dissection of the adhesions with the risk of opening the peritoneal cavity. Nephrectomy is contraindicated in cases of calculous anuria because renal tissue, regardless of the amount, must be conserved even though a considerable portion of it is diseased. Ureterotomy at a low level for removal of the calculus is definitely contraindicated, but ureterotomy at a high level for drainage and removal of the calculus, if in that vicinity, is permissible. Nephrostomy is frequently an important procedure. Pyelotomy is of value, permitting extraction of stones from the renal pelvis and drainage without destruction of renal tissue. Venesection and transfusion should be performed as quickly as possible if the hemoglobin is not reduced too

15. Trattner, H. R., in discussion on Cahill.[14]

much; or, if it is reduced, a transfusion alone, without venesection, should be given.

Watson,[16] in discussing calculous anuria, stated that Cahill's experience in handling 22 cases of this condition shows several important basic principles. Despite the fact that in 9 (40 per cent) of the 22 cases there was no diagnostic shadow on the plain roentgenogram, Watson expressed the belief that the making of a plain roentgenogram should be the first step in cases of this type. As a second step, every effort should be made to pass a ureteral catheter at least part way up the ureter. On several occasions it has been possible to pass a small catheter 1 or 2 cm. beyond the obstructing calculus in the lower part of the ureter of a single kidney and establish drainage. With drainage even imperfectly established the situation can often be changed from one demanding immediate, emergency operative intervention to one of elective operation at a more opportune time. Even in cases of bilateral calculus of the pelvis the passage of a catheter to the pelvis and beyond the stone may establish adequate drainage and may help to prepare the patient for subsequent operation. When readily possible, drainage by pyelotomy is the procedure of choice in cases of calculous anuria not associated with infection or in those in which only mild infection is present. Large renal calculi may sometimes best be handled by nephrotomy. In most instances thorough lavage of the interior of the kidney at operation, with from 1 to 2 quarts (1 to 2 liters) of saline solution, aids in controlling bleeding and may wash out a few small calcareous particles that might later serve as nuclei for further formation of stone. In cases of bilateral involvement operation on both sides (other than drainage) at a single sitting is not considered advisable by Watson.

In a review of 162 cases of stone in the upper part of the urinary tract, Winsbury-White[17] discussed the etiology, clinical features and diagnosis, and particularly the treatment. Despite experimentation with animals to show that dietetic errors influence formation of renal calculi, it is doubtful whether the mixed regimen followed by a modern community has any important bearing on the formation of stone.

The two factors of prime importance are dilatation of the upper part of the tract and a chronic focus of infection in the pelvic organs. The focus may be in the prostate gland and seminal vesicles in male, and in the uterine cervix and adnexa in female, patients.

An important clinical feature of renal lithiasis is absence of symptoms in many cases. The onset of pain and hematuria depends fre-

16. Watson, E. M., in discussion on Cahill.[14]

17. Winsbury-White, H. P.: A Review of One Hundred and Sixty-Two Consecutive Personal Cases of Stone in the Upper Urinary Tract, Brit. J. Urol. **6**:142 (June) 1934.

quently on a definite increase in, or activity of, existing infection, and one must avoid the pitfall of regarding the absence of physical signs as excluding the presence of stone.

Excretory urography is valuable in establishing the diagnosis, the exact situation of the stone, the renal functional activity and the amount of dilatation.

Treatment is discussed under the following subdivisions: (1) small stones capable of passing; (2) presence in one kidney of a stone too large to pass, (*a*) without gross renal impairment or infection, (*b*) with gross renal impairment or infection; (3) presence in one kidney of a stone formed secondarily to hydronephrosis, (*a*) with unilateral dilatation, (*b*) with bilateral dilatation; (4) presence of stones in both kidneys.

There is scope for a considerable variety of treatment, depending on degree of infection, renal function, obstruction and pyelectasis. Recurrences are avoided by complete removal of all fragments, aided by roentgenograms of the exposed kidney. Excision and resection of thinned out and devascularized renal tissue and calices prevent persistence of "pooling" and of pelvic residual urine and is a sound safeguard against recurrences.

Plastic repair of the ureteropelvic junction should be performed whenever obstruction occurs at that point. Nephrectomy rather than a conservative operation is advisable in many cases of unilateral stone, to insure against pyuria, further formation of stone and continued ill health.

In the 43 cases of unilateral involvement in which nephrectomy was performed subsequent formation of stone on the opposite side did not take place in any case. Occasionally nephrectomy is indicated in certain cases of stone in both kidneys if there is gross destruction of renal tissue with infection on one side and a moderately good kidney with little or no infection on the other.

In operating for bilateral calculi, Winsbury-White elects to operate on the less affected side first. The value of nephrectomy in cases in which stones are present in both kidneys is discussed.

There were 55 cases of ureteral calculus; in 45 involvement was unilateral and uncomplicated by renal calculus; in 1 it was bilateral, whereas in 9, a stone was present either in the corresponding or in the opposite kidney.

There were 2 deaths in Winsbury-White's total series of 162 cases, 1 occurring after pelviolithotomy in a single kidney.

Counseller and Priestley [18] stated that the indications and the type of operation for removal of a single stone that is too large to pass spon-

18. Counseller, V. S., and Priestley, J. T.: The Present Conception of Renal Lithiasis, J. A. M. A. **104**:1309 (April 13) 1935.

taneously have been fairly well standardized. In the past nephrolithotomy was the operation of choice for removal of a renal stone, but, except for a stone or stones situated just beneath the renal capsule or impacted high in one of the calices, pelviolithotomy is now the preferable procedure. This is particularly true in cases of a single stone situated in the renal pelvis. By careful manipulation many single or multiple stones situated in the calices can also be removed through incision of the pelvis of the kidney. Removing stones through the renal pelvis does not destroy important structures; large blood vessels are not divided, and satisfactory anatomic closure can be obtained. Fistulas of the urinary tract rarely follow this procedure. Pelvionephrolithotomy is used to advantage when a stone is impacted in a calix or when there are branches extending into one or more calices.

Conservative operations depend on the type, size and situation of the stones, on the presence or absence of infection, on the status of the opposite kidney, on the involvement—whether bilateral or unilateral—on renal function and on the general condition of the patient. There is still considerable divergence of opinion regarding management of the stag-horn or coraliform type of stone. These are frequently symptomless and are discovered only in the course of routine examination; their removal usually has been difficult and has been attended with some destruction of the parenchyma of the kidney. In the past few years it has been possible to remove successfully stag-horn stones from the kidney in most cases; in several of these cases there were stones in both kidneys; serious injury to the kidney, its pelvis or ureter did not take place, and all fragments were removed. The method employed in removal consisted of retracting the parenchyma to the bifurcation of the calices, thus giving direct access to the calices through a V-shaped incision in the renal pelvis. By nephrectomy over each calix the portion of stone in that calix was removed, the forefinger of each hand being used, one in the pelvis and one in the calix. Bleeding from opening of the parenchyma was controlled by suture or by Pezzar catheters pulled snugly into the calix.

Surgical removal of stones from the kidney is not adequate treatment for renal calculi; the postoperative care and management is an important phase of the treatment. This is particularly so if infection is present in the urinary tract or if a definite tendency toward recurrent calculi has been demonstrated. If renal function is materially interfered with, subsequent attention to these factors is of significance. All calculi and fragments of stone should be completely removed at the time of operation if recurrence is to be prevented. This may be accomplished only by the routine use of fluoroscopic and roentgen examination at the time of operation. Although the influence of obstruction of the kidney in

the formation of stones is not fully understood, every effort should be made to provide free drainage of urine from the upper portion of the urinary tract after removal of stones. Not infrequently, because of obstructing factors such as anomalous vessels, bands of fibrous tissue, acute angulation of the ureter or other causes, obstruction may be discovered at the ureteropelvic juncture. This should be corrected if possible at the time of operation. Complete elimination of infection is important in preventing subsequent formation of calculi. Different aids may be used in removing infection from the urinary tract. If the kidney is extensively injured and is the seat of marked infection at the time of operation, it is frequently advisable to insert a nephrostomy tube, preferably through the lower calix, in order to aid rehabilitation of the kidney. This not only provides excellent drainage but permits direct pelvic lavage as often as desired. Various metabolic disorders may fundamentally be responsible for formation of calculi. Routine chemical analysis of the calculus removed may aid in detecting these disorders. In addition, microscopic examination of the urine may reveal cystinuria or the presence of uric acid crystals.

Sutherland [19] stated that 479 patients operated on at the Mayo Clinic for renal calculi since 1924 have been reexamined by means of the fluoroscope for the presence or absence of remaining stones or particles. The procedure in the majority of cases was to make a fluoroscopic examination of the kidney after all appreciable calculi had been removed. No evidence of persisting shadows was revealed in 409 cases of the series. In 70 cases (14 per cent) fluoroscopic observations disclosed persisting shadows which were localized, and the remaining stones or fragments were searched for and removed. In a few instances repeated observations were necessary to accomplish the task successfully.

For some years at the Mayo Clinic, roentgenograms of the kidney have been made at the time of operation; a casette holding a 10 by 12 inch (25.40 by 30.48 cm.) film and intensifying screens have been used. The casette and film are covered with a sterile towel and are held against the side of the patient; the roentgenograms have proved satisfactory. A preliminary observation is made to get the kidney in proper perspective, and a roentgenogram is made and then sent for immediate development. If a shadow is visible it can be localized in subsequent observations, and usually by the time the surgeon has found and removed the calculus or fragment, the finished roentgenogram is available for checking with the surgical findings. Corroboration of the fluoroscopic findings when they are negative or elucidation of shadows not seen by the physician who makes the fluoroscopic examination is hastened by

19. Sutherland, C. G.: Renal Roentgenoscopy and Roentgenography at the Operating Table, J. Urol. **33**:1 (Jan.) 1935.

this procedure, and the information is made available to the surgeon without undue delay.

The apparatus used for making fluoroscopic observations of the kidney at the operating table is essentially the bedside unit used in the majority of hospitals. It consists of a transformer and autotransformer enclosed in a metal cabinet and mounted on large casters for portability. The cabinet is attached to a tube stand with a horizontal arm having universal joints for supporting the tube. The tube is of the Coolidge radiator, self-rectifying type, mounted in a lead glass shield. The ordinary cone is replaced by one 30 cm. in length, with a diameter of 6 cm. at its proximal end and 8 cm. at its distal end. This cone converges the rays on the kidney, and its length allows the unit to be brought closer to the patient without menace to safety.

Herman and Lee [20] stated that lithiasis due to cystine is predominantly a disorder of males. Cystinuria, as has long been known, is an inheritable condition characterized by an essential fault in protein metabolism leading to incomplete oxidation of sulphur. Accordingly, cystine, a sulphur-bearing amino acid, is formed in an amount too great to be excreted chiefly by the kidneys. The condition lacks surgical interest as long as cystine is held in solution, but crystallization is prone to occur, with lithiasis as a frequent result. Lithiasis due to cystine is found in isolated segments of the urinary tract, and nephrolithiasis due to cystine is no more frequently bilateral than are other varieties of nephrolithiasis. Undoubtedly, localization in formation of stone is usually dependent on local factors, but cystine stones may form in the kidney in the absence of infection or demonstrable mechanical defect. Multiplicity of stones and their rapid development are likewise suggestive of lithiasis due to cystine although it is not highly characteristic of cystine calculi in the kidney to grow to enormous proportions, as some authors claim. Data on lithiasis due to cystine, as obtained from roentgen examination, lead to the conclusion that the texture of the stones, as well as the atomic weight of their constituents, determines their radio-opacity. The treatment of urolithiasis due to cystine is the same in principle as that applied in cases of other varieties of urinary stone. However, a more conservative attitude should be assumed toward operative treatment in the case of nephrolithiasis due to cystine for the following reasons: 1. Large cystine stones will pass more readily than large stones of other varieties. 2. There is a marked tendency to rapid recurrence of the condition in the absence of proper postoperative treatment and, some writers claim, in spite of it. 3. In some instances cystine stones may be dissolved. Cystine is soluble in an alkaline medium; this fact rationalizes the admin-

20. Herman, Leon, and Lee, W. E.: Cystine Nephrolithiasis, Ann. Surg. **101**: 746 (Feb.) 1935.

istration of sodium bicarbonate, ammonium carbonate and similar drugs in the attempt to dissolve stones or to prevent their reformation. The only function of alkalis in prophylaxis is to maintain the solubility of cystine in the urine; this substance in cystinuric patients is constantly present in excessive amount, and a strong tendency to crystallization exists. Dietary regulation is based somewhat on empirical grounds, although the rate of excretion of cystine is in direct ratio to the protein content of the diet. The limitation, if not the exclusion, of proteins from the diet, particularly of those rich in sulphur, is a rational phase of prophylactic treatment.

Surgical Technic.—Colston [21] stated that the term "complete nephro-ureterectomy" should be used to describe only the operation in which complete excision of the upper part of the urinary tract, including the intramural portion of the ureter, has been performed. A simplified technic has been described, by which complete nephro-ureterectomy can be accomplished, avoiding the technical difficulties and postoperative complications which may occur when a cuff of mucous membrane about the orifice of the ureter is excised. After sectioning the ureter above the bladder Colston removes the clamp on the bladder side of the ureter, and the lumen of the stump of the ureter is completely destroyed by a fulgurating electrode. In many cases of renal tuberculosis, in addition to nephrectomy there is also a definite indication for ureterectomy. Although a superficial tuberculous invasion of the ureter will heal spontaneously when the diseased kidney above it has been removed, there are certain cases of extensive, deep-seated ureteritis which must be responsible for the occasional infections of the wound which are seen and for sinuses which may persist after simple nephrectomy. The extent of the tuberculous process in the ureter can best be determined by study of the ureterogram. Alternate regions of constriction and dilatation, with a moth-eaten appearance of the edges of the pyelographic medium in the ureter, indicate extensive ulcerative tuberculous ureteritis. In such cases excision of the ureter is necessary. The operation of nephro-ureterectomy, or ureteronephrectomy, is easily performed from a technical standpoint and entails little more shock to the patient than simple nephrectomy.

Despite the fact that the tendency in renal surgery is toward conservatism, resection of the kidney is performed relatively infrequently.

The resections are of two types: (1) resection of normally formed kidneys, and (2) resection of half of a double kidney.

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21. Colston, J. A. C.: Complete Nephro-Ureterectomy: A New Method Employing the Principle of Electrocoagulation to the Intramural Portion of the Ureter, J. Urol. **33**:110 (Feb.) 1935.

Kretschmer [22] reported ten resections of the first type and six of the latter. As a rule, the operation is performed more frequently on double kidneys, usually for hydronephrosis and infection, with or without stones. It may become an operation of necessity on solitary kidneys, in cases of circumscribed collections of stones, especially with infection, of stones in a calix, with dilatation and with strictures of the neck and of encysted stones with formation of abscess or carbuncle. It may be an operation of choice when these conditions are present in one of two kidneys. Additional indications are encountered in the following instances: (1) in cases of stone in both kidneys in which one pole is diseased or in cases in which there exists a circumscribed stone with formation of pus; (2) in cases of partial hydronephrosis of the upper or lower pole, with formation of stone; (3) in cases of solitary cyst of the kidney, in which group resection is at present recognized as the operation of choice and, as a rule, is simple and easy of execution; (4) in cases of double kidney with double pelvis, in which one-half gives evidence of the presence of hydronephrosis, severe infection or stone.

In Kretschmer's series hemorrhage was not troublesome either at the time of operation or subsequently.

In the cases of double kidney, the vascular supply to the diseased half was ligated before the resection was performed, and the operation was practically bloodless. In normally formed kidneys there was no difficulty in controlling the bleeding with sutures.

Postoperative fistula did not occur. It can be prevented by careful suturing of the opened calices and parenchyma.

Tuberculosis.—Woodruff and Bumpus [23] stated that there is sufficient laboratory, as well as clinical, evidence that tuberculous infection of the kidney actually heals. Healing, however, does not prohibit reinfection. There should be adequate hygienic treatment of renal tuberculosis in its early stage, preferably in a sanatorium. Nephrectomy should be performed only when evidence of extension of the disease exists, when caseocavernous conditions can be demonstrated, or when, on test, it is evident that renal function has become markedly diminished.

Greenberger, Wershub and Auerbach [24] reported that of 500 cases of tuberculosis in which necropsy was performed, in 252 evidence of tuberculous infection of the kidney was found. Miliary tubercles that

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22. Kretschmer, H. L.: Resection of the Kidney, Surg., Gynec. & Obst. **60**: 984 (May) 1935.

23. Woodruff, S. R., and Bumpus, H. C., Jr.: Is Nephrectomy Always Indicated Following a Diagnosis of Unilateral Renal Tuberculosis? J. A. M. A. **104**: 716 (March 2) 1935.

24. Greenberger, M. E.; Wershub, L. P., and Auerbach, Oscar: The Incidence of Renal Tuberculosis in Five Hundred Autopsies for Pulmonary and Extrapulmonary Tuberculosis, J. A. M. A. **104**:726 (March 2) 1935.

could be recognized grossly were found in 228 cases (45.6 per cent). In this group the involvement was found to be bilateral in 187 cases (82 per cent) and unilateral in 41 cases (18 per cent). The youngest patient of this series was 9 months old, and the oldest, 74 years; the average age was 36. In the group were 157 male and 71 female patients; there were 154 patients belonging to the white, 72 to the Negro and 2 to the yellow race. Only 25 per cent of the patients had urinary symptoms. The most common complaints were nocturia and frequency.

Of the total number of cases in which necropsy was performed, "organ tuberculosis," that is, destruction of the renal substance, was found in only 24 cases (4.8 per cent). In this group the involvement was found to be bilateral in 13 cases (54 per cent) and unilateral in 11 cases (46 per cent). The youngest patient was 23 and the oldest 59 years of age; the average age was 39. There were 20 men and 4 women; 21 white patients and 3 Negroes. In 60 per cent of the cases in this classification there was some evidence of urinary disturbances; these were mild as compared to the pathologic changes found at post-mortem examination.

In 16 cases the tuberculosis was extrapulmonary and the renal involvement bilateral. In all but 1 case the disease was of the miliary type. The youngest patient of this group was 1½, and the oldest 56 years of age; the average age was 22. The cause of death was tuberculous meningitis in 10 cases, tuberculous peritonitis in 4 cases and generalized miliary tuberculosis in 2 cases. Organ tuberculosis is the pathologic condition most frequently encountered by the clinician and urologist. It is the type of lesion that produces definite changes as revealed by pyelograms and is clinically recognizable.

Young,[25] in discussing a paper read before the Section on Urology of the American Medical Association, stated that the subject of urogenital tuberculosis is of such importance that thorough consideration should be given to it before presenting to the medical world the statement that the Section on Urology even contemplates the advisability of not performing nephrectomy in the presence of an early tuberculous lesion on one side. The diagnosis of this disease is difficult. Tubercle bacilli are not always to be found in the urine, and guinea-pigs do not always die after receiving injections of urine from a patient who has definite renal tuberculosis. After a careful recent study of all his cases of tuberculosis of the genito-urinary tract Young is convinced not only that early nephrectomy and partial ureterectomy are desirable but that whenever tuberculosis has involved an epididymis it is practically certain that the vasa deferentia, seminal vesicles and prostate gland are also involved, in which case bilateral radical operation on the seminal tract is indicated as soon as the patient has recovered from the nephrectomy.

25. Young, H. H., in discussion on Woodruff and Bumpus.[28]

LeComte [26] stated that definite distinction should be made between healing of a lesion of renal tuberculosis and cure of the disease in the entire organ. Some evidence of healing may be found in practically every tuberculous kidney, but the occurrence of a complete cure may be questioned. To regard a cure as established in a surgical form it would be necessary to show that the previously diseased kidney was capable of secreting a urine free from pus and bacilli and was free from evidence of the disease both on urography and on other roentgen study. LeComte deplored the tendency to discontinue the use of operation in cases of early unilateral tuberculosis of the kidney; it is in these instances that the best results are obtained.

Eisendrath [27] stated that renal tuberculosis and true calculus are associated in approximately 1.8 per cent of all cases of renal tuberculosis. He tabulated 40 cases, reported since 1920, the majority of which were instances of formation of true calculi in tuberculous kidneys; 5 of these cases were personally observed. The cases are divided into four clinical groups, the first two of which are of especial importance. In the first group, if the concomitant tuberculosis in a case of calculus of the kidney or ureter is overlooked, there is danger of formation of a persistent postoperative fistula as well as of early recurrence of calculi. Five cases reported since 1920 of calculous anuria following nephrectomy for tuberculosis at intervals of from twenty-six days to one year are cited. A number of similar cases were reported before 1920 by Eliot, Kuemmell and others. The making of plain roentgenograms even in cases of well marked renal tuberculosis should be considered a routine measure in order to detect the presence of renal or ureteral calculi.

Gibson [28] stated that the common definition of autonephrectomy is "a stricture of the ureter which completely closes the lumen so that no secretion reaches the bladder." This definition does not give the true meaning of the word. Autonephrectomy should be said to have taken place in cases of renal tuberculosis in which there is not only complete closure of the ureter, with cessation of all symptoms, but also complete destruction and transformation of the kidney into a quiescent, shrunken caseosclerotic mass, so that surgical removal is unnecessary.

Two cases of autonephrectomy are reported. One is unusual in that complete calcification of the kidney and ureter occurred and that tuberculosis of the urinary tract had existed for thirty-five years. Approximately 0.5 per cent of tuberculous kidneys undergo complete calcification. With quiescent total calcification coincident with a normal bladder, the

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26. LeComte, R. M., in discussion on Woodruff and Bumpus.[23]

27. Eisendrath, D. N.: Renal Tuberculosis and Nephrolithiasis as Associated Diseases, Surg., Gynec. & Obst. **60**:77 (Jan.) 1935.

28. Gibson, T. E.: Nephrectomy Versus Autonephrectomy in Renal Tuberculosis, J. Urol. **33**:145 (Feb.) 1935.

prognosis appears to be equally favorable whether the patient is treated medically or surgically. In the problem of nephrectomy versus autonephrectomy the conclusion seems justified that in certain cases of unilateral renal tuberculosis, conforming to the definition of autonephrectomy suggested by Gibson, nephrectomy is not necessary, or at least the risk of noninterference is no greater than the risk of nephrectomy.

Hydronephrosis.—Ragnotti [29] undertook researches in which he subjected the ureters to mechanical or chemical denervation in order to discover whether the genesis of the so-called "dynamic hydronephrosis" lies in pure and simple lesions of nerve tissue, or whether, and to what extent, anatomic factors also play a rôle in its production. Comparing the histologic observations on the treated ureters with their functional behavior and with the lesions presented by the kidneys he concluded that when the denervation is brought about by chemical means (isophenol) the simple change of innervation induces nothing more than transitory modifications of ureteral motility, almost exclusively affecting the peristaltic and not the pendular movements, and does not go so far as to provoke permanent and progressive anatomic lesions and, still less, hydro-ureteronephrosis, since the changes never get beyond the phase of reversibility and tend to disappear on regeneration of the intrinsic nervous system.

But when the lesion of the innervation results also in modification of the histologic structure of the ureter, as usually occurs when denervation is brought about by mechanical means (adventitiectomy, decortication of the ureter) producing sclerotic changes in the organ, the diminution of motility is more pronounced; to this is added alteration of the normal elasticity and distensibility of the ureteral wall since there is constant formation of a periureteral connective tissue which at the periphery causes adhesions and centrally has a tendency to infiltrate, disorganize and replace the muscle fibers, until in advanced cases there occurs a true replacement of connective tissue of the tunica muscularis capable of profoundly changing the kinetics of the ureter. This interruption of the continuity of the muscular tunic must produce far graver consequences than simple destruction of the rete nervosa. For the process of sclerotization of the muscular tunic not only results in functional disturbances through changes of the normal elasticity and distensibility of the ureteral wall, tending to obstruct the normal outflow, but may also be the cause of a true mechanical obstacle when it produces cicatricial stenosis, angulation and kinking of the ureter. But not even

29. Ragnotti, Ercole: Considerazioni e ricerche sul significato patologico e sulla produzione sperimentale della "idronefrosi dinamica": Conseguenze anatomiche e funzionali della enervazione periureterale, Arch. ital. di chir. **38**:367 (Nov.) 1934.

in these cases does atony (inertia) supervene (unless indeed the sclerosis is total), but rather dyskinesia of the entire ureter occurs. The existence, however, of automatic movements does not preserve the kidney from the appearance of graver lesions, since these movements are no longer endowed with expulsive activity.

Mechanical denervation has as its result, therefore, a hydronephrosis which, lacking the causal factor of stenosis, must with good reason be regarded as attributable to injury to function or in other words as "dynamic." The basis of this "dynamic hydronephrosis" is, however, anatomic in a strict sense, that is, it is connected with anatomopathologic changes of the wall of the ureter and is not the pure and simple result of the lesion of nerve tissue.

Kimbrough [30] stated that the conservative treatment of hydronephrosis is essential in cases in which etiologic factors are bilateral. Satisfactory results have been obtained by plastic surgery in cases in which the hydronephrotic sacs have been large, in those in which there has been stricture at the ureteropelvic juncture, in cases of anomalous renal position and in cases in which obstruction has been caused by large, aberrant vessels. Complete relief from clinical symptoms is not always obtained, but the moderate morbidity resulting in some cases is compatible with a comfortable existence and is only a small handicap to gainful occupations. The type of operation must be selected to meet the requirements in each individual case. The following points are important in the surgical treatment of hydronephrosis: drainage by nephrectomy, splinting by ureteral catheter, adequate perirenal drainage, fixation of the kidney in proper position, renal sympathectomy to improve circulation and prevent postoperative pain, avoidance of division of large aberrant vessels and correction of deformity of the proximal portion of the ureter.

Trauma.—Mauro [31] discussed the means of diagnosis in cases of ruptured kidney in which the fact of trauma has been concealed from the surgeon, as in a case recently observed by him. The mechanics of this rupture was one that he has not found in the literature: A fall flat on the abdomen caused a large, coraliform calculus to puncture with its point the renal artery at its entrance to the pelvis, and a grave retroperitoneal hemorrhage resulted. The enlarged kidney, which was ptotic, had been pushed against the spinal column by the blow, at the transverse processes of the second and third lumbar vertebrae; the wall of the

30. Kimbrough, J. C.: Surgical Treatment of Hydronephosis, J. Urol. **33**:97 (Feb.) 1935.

31. Mauro, Mario: Su di un nuovo meccanismo di rottura del rene: Contributo allo studio della sindrome acuta emorrhagica retroperitoneale, Ann. ital. di chir. **13**:819 (July 31) 1934.

renal pelvis and the hilus had been pushed out of place and injured between the stone and the bony resistance of the spine. The breach in the pelvis had remained plugged by the calculus, and it was the lesion of the artery that caused the rapid hemorrhage into the retroperitoneal space. The slightness of the hematuria in this case was deceptive; it was followed by anuria either from reflex action or from renal blockade.

In cases of this kind the retroperitoneal syndrome caused by the rapid hemorrhage into the perirenal cellular tissue is characteristic. The toxic symptoms that arise give Mauro the impression that there is rapid and marked absorption of substances formed as the result of undeniable changes of the blood that has escaped, possibly an intoxication of the vegetative nervous system through absorption of protein substances produced by changes in the extravasated blood.

When the fact of trauma has been concealed, as in this case, diagnosis is difficult, especially if renal signs are not evident and if the perirenal hematoma is not readily perceptible, owing to excessive abdominal rigidity and absence of fulness in the lumbar region. One thinks rather of rupture of the liver or spleen to explain the anemia and the peritoneal reaction, or of intestinal occlusion—a diagnosis that is often made. The presence of a concomitant abdominal lesion, of course, leads to confusion and aggravates the symptoms.

Lancinating pain, frequently syncopal in its effects, is always present at the start, just as it is in cases of ruptured extra-uterine pregnancy. The pain is often accompanied by shock and loss of consciousness, and even by collapse; the temperature may be elevated from rapid absorption of blood, or lowered from shock. The lumbar region is usually sensitive and contracted, the abdomen is meteoric and pain is elicited on pressure. Rigidity is a characteristic sign; it may hinder good palpation and make it impossible to discover the perirenal hematoma.

In Mauro's case the blood was diffused in the surrounding subperitoneal connective tissue down to the crest of the ilium and had widely detached the peritoneum toward the median line. Nephrectomy was inevitable, not only for hemorrhage but also on account of the precarious condition of the organ.

Abeshouse [32] stated that rupture of the pelvis of the kidney proper is a relatively rare condition; it may be of the traumatic or of the spontaneous type. Rupture of the pelvis of traumatic type may occur in a congenitally normal kidney or in a kidney that is the site of acquired inflammation or obstruction. The rupture is usually the result of direct or indirect trauma exerted against the kidney. The spontaneous type of pelvic rupture usually occurs in a kidney which is the seat of a chronic

32. Abeshouse, B. S.: Rupture of the Kidney Pelvis: Review of the Literature, Surg., Gynec. & Obst. **60**:710 (March) 1935.

pyelonephritic process or of which the pelvis is dilated as the result of obstruction of the ureter or of the pelvis. Rupture of a pathologically weakened pelvis may also occur as the result of instrumental perforation, or it may follow the exertion of increased pressure in the syringe method of pyelography. In rare instances perforation may be attributable to chemical necrosis following injection, by mistake, of a strong alkali in the course of pyelographic studies or renal lavage.

The traumatic type of rupture has a greater incidence than the spontaneous type. The former apparently occurs more frequently among males than among females. The spontaneous type occurs with about equal frequency in both sexes. There is no definite complex of symptoms or clinical syndrome that is absolutely typical or constantly associated with rupture of the pelvis of a kidney. The presence of the lesion should be suspected if there is an antecedent history of chronic pyelonephritis or hydronephrosis secondary to calculus in the pelvis or ureter and if there is a sudden, sharp pain in the renal region followed by sudden or gradual swelling or the appearance of a mass in the same region, accompanied by chills, fever, nausea, vomiting and—frequently—shock or collapse. The clinical impression that the pelvis is ruptured should be confirmed by urologic study, including pyelography, which is the only dependable method of diagnosis.

Successful treatment in cases of ruptured pelvis is directly dependent on early diagnosis and immediate surgical intervention, which may be either conservative or radical. The conservative procedure includes incision and drainage and, if possible, correction of pathologic processes responsible for rupture and repair of the pelvic laceration. The radical procedure is nephrectomy, provided the opposite kidney is healthy. In the case of toxic and debilitated patients treatment should be in two stages: preliminary incision and drainage followed by nephrectomy or conservative repair at a later date.

Cysts.—Quinby and Bright[33] stated that there are three varieties of large, single cysts of the kidney: The first is the simple, thin-walled cyst containing a serous fluid. This type of cyst, although formed of the parenchyma of the kidney, bears no anatomic, causal relation either to the pelvis or to a calix. Of the second variety are cysts which, although they compress and push aside the secretory tissue of the kidney in the same way as do cysts of the first type, have a deeper origin and communicate with some portion of the renal pelvis by a minute channel; these are designated as pyelogenic cysts by some writers. A third variety includes cysts which lie outside the kidney proper, communicating

33. Quinby, W. C., and Bright, E. F.: Solitary Renal Cysts: Their Symptoms When Situated at the Upper Pole of the Right Kidney, J. Urol. **33**:201 (March) 1935.

with the pelvis but not representing a true dilatation of it as does the pyelectasis associated with hydronephrosis. These form the so-called parapelvic type of cysts. There is also described a fourth variety, the hemorrhagic solitary cyst, the name being derived from the content of the cyst.

An analysis of the symptoms associated with these cysts of the upper pole of the right kidney has been made from 32 cases, reports of which have been found in the literature, together with the 4 instances reported by Quinby and Bright. More than 50 per cent of the patients had pain in the right upper quadrant of the abdomen, under the costal margin. This pain usually did not radiate. A few patients complained only of discomfort in that region. One fourth of the patients had pain in the right side of the back. The pain extended anteriorly in a few of these cases, and sometimes it extended down the course of the ureter. In one third of the cases there were symptoms of cystitis, and in one third also chills and fever were reported. In two thirds of the group neither the kidney nor any tumor could be felt. When the cyst was palpable it usually was so abdominally, not bimanually. Only a few patients complained of tenderness on palpation. In about two thirds of the cases, therefore, physical examination gave entirely negative results. Pyelography in the 8 cases in which it was performed gave the most accurate diagnosis, disclosing deformity or displacement of the upper calices in 75 per cent of the cases. In reviewing a large number of cases of solitary cyst of the kidney situated at other sites than the upper pole of the right kidney it was found that there were 41 cases in which pyelography was recorded; in 34 (83 per cent) of these cases pyelograms showed abnormal conditions. Accurate preoperative diagnosis of cysts of the upper pole of the right kidney has rarely been made. Only in 1 of Quinby and Bright's 4 cases and in 5 of 30 reported instances was a correct diagnosis made.

Ptosis.—Spurr [34] undertook to prove by experimentation that weakness of the abdominal wall and diminution of intra-abdominal pressure do not play the important rôle that currently has been assigned to them in the production of movable kidney. As a result of his studies he was convinced that in a great number of cases nephroptosis is only the most important symptom of a general dyscrasia, as has repeatedly been asserted by Pende, Stiller, Tuffier and others, and is accompanied, among other things, by splanchnoptosis, the nature of which should be understood. Without undertaking to resurrect the old theory of Glonard, that enteroptosis is the chief cause of renal displacement, or the anatomic theories of Longyear, it cannot be denied that if one always checked

34. Spurr, Ricardo: Nefroptosis y esplacnoptosis, Rev. méd. latino-am. **20**:1 (Oct.) 1934.

up the state of the abdominal viscera in cases of movable kidney one would cease to be surprised by the discovery that the stomach, duodenum, liver and colon suffer an appreciable, and in some cases, a considerable displacement, explaining the digestive symptoms observed in patients with movable kidney. All authors who have given attention to splanchnoptosis, and especially to gastroptosis, have confirmed the theory that displacements of the digestive tube are always accompanied by displacement of the right kidney or of both kidneys. This is explained by the intimate anatomic relation of the right kidney with the second portion of the duodenum, with the ascending and transverse colon and with the liver, as well as by that of the left kidney with the transverse and descending colon. Since 1922 Spurr has systematically carried out examination of the digestive apparatus of patients with movable kidney and has found in all of them a marked splanchnoptosis, as the roentgenograms accompanying his article show. The existence of nephroptosis and splanchnoptosis, as associated lesions in young patients presenting symptoms of the "vagotonic type of Pende," or the "asthenic habitus of Stiller," seemed to Spurr a sufficient justification for reaffirming the foregoing concept of their etiopathogenesis and for basing his treatment on this premise.

Spurr has found that the surgical fixation of all the organs involved in this combined splanchnoptosis and nephroptosis has always been followed by frank improvement of digestive symptoms, particularly of gastric disturbances, as well as of renal troubles. The operative method which he proposes, and which he has used with good results in 31 cases, he has named cologastrohepatopexy; it comprises five stages, as follows: (1) right rectus incision, 12 inches (30.5 cm. long); (2) appendectomy; (3) exteriorization of the stomach and colon, which are held by Chaput's forceps and an anterior bandlet; (4) fixation of the colon to the anterior aspect of the stomach, with folding "à besace" of the gastrocolic epiploon, and (5) shortening of whatever ligament is at fault. Whenever third degree nephroptosis is present or the patient has symptoms of uronephrotic retention, or renal colic, nephropexy naturally should be performed; this can best be accomplished at the time of the second of the five stages, if renal accidents dominate the clinical picture. However, a patient with a movable kidney should be treated by nephropexy even if the condition has not provoked any acute renal symptoms, in order to prevent complications that might arise later.

Spurr observed that the usual procedures for fixing ptosed viscera to the abdominal wall have the disadvantage of changing the intra-abdominal status and of contracting visceral adhesions that may cause functional disturbances, if indeed the graver complications of volvulus and occlusion by bands do not occur. Impressed by the methods of Beyea and Bier, he believed and demonstrated that he could satisfactorily correct

splanchnoptosis by shortening the great omentum in its gastrocolic portion and fixing the transverse colon to the anterior wall of the stomach; the latter in turn is lifted to a good position by shortening of the gastrohepatic omentum, and the liver is lifted by shortening of the falciform ligament. This method obviates the disadvantages inherent in the type of right nephropexy carried out in Argentina by Alberto Gutierrez, who closes the renal fossa on its lower side and fixes the right colic angle to the upper pole of the kidney (divested of its serosa) and to the parietal peritoneum, a method that results in changes of the intra-abdominal status. No disturbances of the digestive apparatus have resulted in any case in which Spurr has used his cologastrohepatopexy, with or without nephropexy, according to the conditions present, and the intra-abdominal status has suffered no detrimental change.

(To be concluded)

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